March 30, 1951

THE ENGINEER

A Seven-Day Journal

Railway Freights

The Minister of Transport, Mr. Barnes, stated in the House of Commons on Thursday of last week that, as a result of recent increases in railway wages and other substantial increases in its costs, the British Transport Commission estimated that at current levels of charges there would be a deficit of £25,000,000 on its net revenue for 1951. That sum, he said, was additional to the Commission's accumulated deficit on revenue account, which, at the end of 1950, amounted to £40,000,000. In the light of its financial situation, the Minister continued, the Commission had asked him to exercise his powers under Section 82 of the Transport Act with a view to an immediate increase of 10 per cent in railway freight charges, parcel rates and dock and canal charges. The total yield of that increase in a full year was estimated at £20,000,000. Mr. Barnes said that, as required by the Act, he had consulted the permanent members of the Transport Tribunal and expected shortly to receive their advice. The present procedure, he added, was intended as an immediate relief to the Commission and to prevent an undue enlargement of its deficit during the period required for its charges schemes. The date of operation of the passenger schemes, which would be submitted shortly, would be determined by the Tribunal, and the freight scheme would follow.

Jubilee of the I.E.E. South Midland Centre

This year marks the Jubilee of the South Midland Centre of the Institution of Electrical Engineers. To celebrate the event, the centre is holding an exhibition in the examination room of the College of Technology, Birmingham. The exhibition was opened by the Lord Mayor of Birmingham on March 20th and remains open to-day and to-morrow from 11 a.m. to 8.30 p.m. Its aim is to demonstrate the progress of electrical science and its products during the past fifty years and, for convenience, the exhibits are divided into four sections—radio, measurements, supply and utilisation—in accordance with the corresponding groups of the Institution. The South Midland Centre, or the Birmingham Local Section, as it was then called, held its inaugural general meeting on February 27, 1901, under its first chairman, Dr. Oliver Lodge, D.Sc., F.R.S. Sir Oliver Lodge, as he became later, maintained close contact with the Institution through its local section throughout his active life, his last recorded contribution to the local meetings being on April 25, 1928, when he was seventy-seven. For the first thirty-two years of its life the general meetings of the centre were held at the University in Edmund Street. In March, 1919, Dr. Garrard, the then chairman of the centre, reported a proposal to celebrate the Watt Centenary in Birmingham by establishing an Engineers' Building in the city. It was not until 1933, however, that the James Watt Memorial Institute was opened and began to serve as a regular meeting place for the South Midland Centre and for several other engineering associations. On two occasions the I.E.E. summer visits have been held in Birmingham and district. The first of these was in 1925, when the local chairman was Mr. Walter Lawson and the programme included visits to Droitwich broadcasting station, Stourport power station and a number of Birmingham firms. On the next occasion, in 1938, Mr. H. Hooper was chairman and Hams Hall power station was among the places visited. At its inaugural meeting, in 1901, the centre had a membership of 110, which has grown, to-day, to just over 3000. As its interests and activities spread, the centre began to form specialised groups. In 1943 a Wireless Group, now known as the Radio Group, was created, under the chairmanship of Dr. W. Wilson. Five years later a Transmission and Installation section was formed, with Mr. D. P. Sayers as its first chairman. The South Midland Centre owes much to the long service rendered by the five honorary secretaries, who have spanned the fifty years of its existence, beginning with Dr. D. K. Morris (1900–1906) and including Mr. H. Hooper, who held the office continuously from 1922 until his death in 1949, with the exception of the sessions when he served as chairman and past chairman.

Jubilee of the British Standards Institution

The British Standards Institution attains its golden jubilee this year, and as part of the celebrations an exhibition is being arranged at the Science Museum, South Kensington, from June 18th to 28th. The Institution, it will be recalled, came into being in 1901 as the Engineering Standards Committee. Sir John Wolfe Barry, who was then President of the Institution of Civil Engineers, persuaded the Council of that Institution to appoint a committee to consider standardisation of iron and steel sections, and the first meeting of the committee was held in April, 1901. It was then decided to extend the committee to include representatives of the Institution of Mechanical Engineers, the Iron and Steel Institute and the Institution of Naval Architects and, subsequently, the Institution of Electrical Engineers. The Engineering Standards Committee of the Institutions was incorporated as the British Engineering Standards Association in 1918 and was granted a Royal Charter in 1929. With the growth of demand for standardisation from other industries than engineering, however, it became necessary to change the name of the organisation again and the title British Standards Institution was adopted in 1931. At the forthcoming jubilee exhibition, the benefits derived from standards, standardisation and simplification will be graphically presented, and each industry will show how standards have simplified production, reduced costs and maintained quality. The exhibition will also demonstrate how research at one end of the production chain and quality control at the other are linked with and helped by standardisation. In addition, there is to be a display of apparatus used in testing for compliance with British standards. The President of the Board of Trade will open the exhibition at 11.30 a.m. on June 18th.

Dock and Harbour Authorities' Association

The annual meeting of the Dock and Harbour Authorities' Association was held last week, and in his speech Sir John Anderson, the President, defined certain factors which affect the problem of the turnround of ships. It was, Sir John said, a most urgent and vital matter, and he thought that in many ports the handling of ships left much to be desired. During his recent tour of Australian and New Zealand ports Sir John said that he had called attention to three factors which had to be taken into consideration. They were the provision of mechanical aids, co-ordination between all the port interests, and effective supervision of all operations to eliminate abuses. He went on to refer to the preparation of schemes by the Docks and Inland Waterways Executive and mentioned the ports covered by the review of the Executive. Sir John commented that no scheme was sufficiently advanced to the point at which a draft order was ready to be promulgated, and that the Association hoped to resolve a number of points of interpretation. Some authorities, he said, had postponed developments owing to the uncertain future of the docks and harbours, but the Association advised that a normal course of action should be followed.

Lloyd's Register of Shipping

This week the general committee of Lloyd's Register of Shipping has announced the formation of another committee. The new body, which consists of a chairman and six members, has been established recently in Australia to advise on matters which may arise affecting the work and interests of the Society in that country and in New Zealand. This committee will be under the chairmanship of Lieut.-General Sir Leslie Morshead, K.C.B., K.B.E., the general manager of the Orient Line in Australia, and the other members appointed are :—Mr. W. E. C. Gregory (Port Line, Ltd.), Mr. Norman E. Jones (Broken Hill Proprietary Company, Ltd.), Mr. G. K. Kryger (Wilh Wilhelinsen), Mr. M. V. Miller (Union Steamship Company of New Zealand, Ltd.), Mr. I. J. Parker (Huddart Parker, Ltd.), and Mr. A. G. Potter (Birt and Co. (Pty.), Ltd.).

Department of Scientific and Industrial Research Annual Report

The report for the year 1949–50 of the Department of Scientific and Industrial Research was published last week and mentions nearly one thousand researches, completed or being studied, from most industries. In the report of the Advisory Council mention is made of new establishments including notes on basic research, and examples are given of the way in which national needs are being met. Special mention is made of operational research, the examination of physiological and sociological factors, including process research and studies of workshop practice, transport, lighting, heating and ventilation problems. All have a bearing on the wellbeing of industry by assisting in recruitment and in raising productivity. Another investigation concerns the problem of glare and the report states that, as a result, new lighting fittings have been developed. An allied problem has been the proper use of colour in factories to reduce eyestrain and so improve production. The gravity of the sulphur supply situation has led to experimental work which has shown that sulphur can be produced by micro-biological means. Other work, according to the report, has demonstrated that sulphur can be recovered from the "spent" oxides at gasworks and a process for regenerating sulphuric acid from "spent" pickling liquor is ready for semi-scale tests. The report also notes that research in the use of pulverised coal for gas turbines is proceeding and that a vortex combustion chamber with a high rate of heat release has been designed. In the hydraulics research section work has been in progress on five models to ascertain the effect of dredging and the construction of piers, and to investigate channel movements and the building of weirs. Another item recorded is the fitting of a new design of air inlet to existing furnaces, which has resulted in increased steel output. Appendices to the report give the names of members of the various research boards, name fifteen establishments of the department and list forty research associations which receive grants.

Cross-Channel and Coastwise Cargo Ships

By G. W. TRIPP, O.B.E., F.C.G.I., M.I.C.E.

THE development of the ocean liner has been fully described from time to time, and the evolution of the cross-channel passenger and mail steamer has also received a degree of attention, but the cargo vessel has rather escaped notice (although perhaps one of the best dividend earners), and it is felt that an article on this craft might prove of interest.

The first steamers to operate regularly in English waters began service about 1815, three years after the celebrated "Comet" appeared in Scotland, a wooden vessel of but 25 tons and having a length of 40ft, with a breadth of 10½ft. She was originally propelled by four paddle wheels, but after two had been removed greater efficiency was obtained. Although many shipbuilders boldly affirmed that to build a ship of greater specific gravity was "contrary to Nature," iron soon superseded wood for ship construction, and from 1821 onwards a large number of iron steamers were built. Many of the steamers of this period were intended for the carriage of mails and passengers as well as cargo; indeed, the steamship established itself as a means of transport before the railways, for the latter were dependent upon the laying of a permanent way, with bridges, embankments, cuttings, &c., to be provided, while the steamer, content with very primitive piers and wharves, had a perfectly free "permanent way."

In 1824 one of the oldest British steamship companies, the General Steam Navigation Company, came into being, a line destined to contribute largely to the development of the type of vessel under our present consideration. For many years the vessels employed continued to cater for both passengers and cargo; some of the once famous paddle steamers engaged on the trade between London and such Continental ports as Ostend had very good accommodation for passengers, while the voyage between London and Leith was made by many people in these semi-cargo boats. In 1842 Queen Victoria and Prince Albert travelled from Leith to London on the "Trident," a wooden paddle steamer of 971 tons gross, having a length of 192ft and a beam of 28ft 7in. Her engines developed a n.h.p. of 280. The Queen described her in her diary as a "fine large and very fast steamer," stating that the accommodation was superior to that of the "Royal George," the Royal yacht.

From 1824 to 1837 this company alone built or acquired fifty-one wooden paddle steamers, but in 1838 the "Rainbow" appeared; she was a smart iron paddle steamer of 407 tons gross, with a length of 185ft and a breadth of 24ft 2in. She was, however, regarded as somewhat of an experiment, seeing that at least nineteen wooden vessels subsequently joined the fleet, the "Perth," of 1861, being the last. All of them were paddle boats. The "Rainbow" was a remarkable steamer in many ways, not only because she was the first seagoing ship to be built entirely of iron, but also because her speed of 12 knots was considered remarkable for a vessel of this type. She was driven by steeple engines of a n.h.p. of 90, the cylinders having a diameter of 50in with a stroke of 54in. The paddle wheels, which were fitted with feathering floats, had a diameter of 21ft 6in. The "Swallow" and "Swift," two paddlers of 1875, were the last of this particular type, and their principal dimensions were: 200·5ft long, 27·2ft beam, 14·5ft depth, tonnage 626 gross. They were driven by engines (built by John Penn and Sons, Greenwich) which were of the oscillating cylinder compound type, with cylinders 45in and 75in diameter and a stroke of 57in, and a steam pressure of 60 lb per square inch, giving a n.h.p. of 160. Paddle steamers continued to be built after this, but only for the seasonal coastwise excursion services, the last of which was the famous "Royal Eagle," built in 1932. At this point mention should be made of the fact that there is still in existence one paddle cargo steamer, the "Lord Elgin"—Fig. 1—which plies regularly between Southampton and Cowes, and is reputed to be still a good dividend earner. Originally built as a pleasure steamer, she was later adapted exclusively to cargo work.

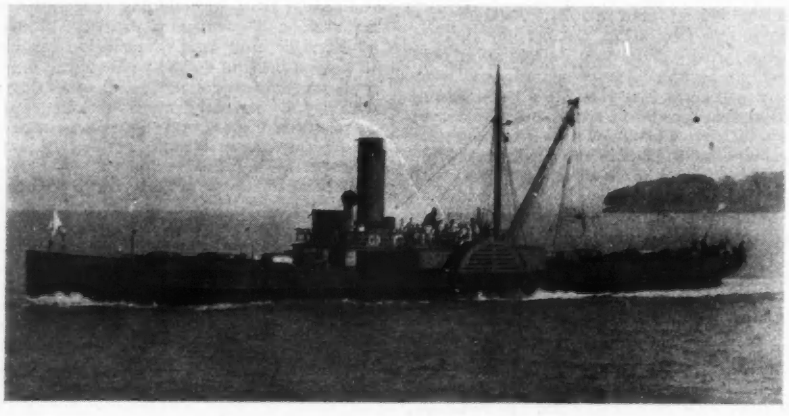


FIG. 1—"LORD ELGIN" PADDLE CARGO STEAMER

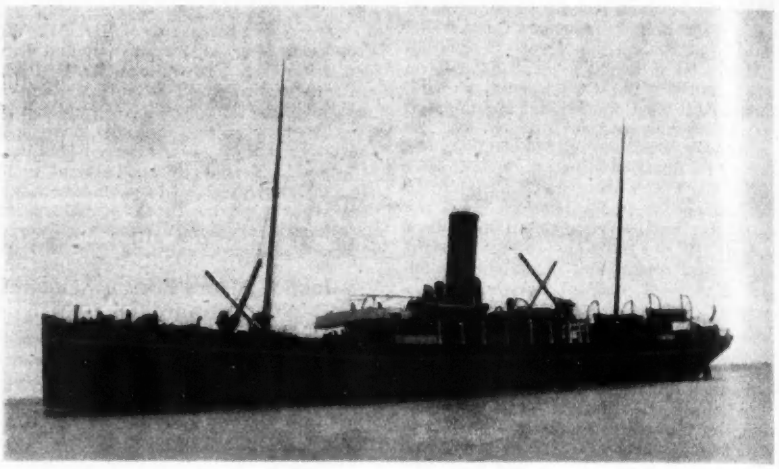


FIG. 2—S.S. "HIRONDELLE"

When in 1862 the railway companies obtained parliamentary powers to own and operate steamers, a large part of the cross-channel cargo traffic fell into their hands, and they built two classes of vessel, the fast passenger mail boat and the cargo boat, the latter setting a high standard, and they were mostly handsome craft. The private companies, while still maintaining cross-channel services, largely concentrated on coastwise traffic, and many of their services are still in being. They continued to build vessels for both passenger and cargo work on the most important passages, and those dispatching cargoes favoured the semi-passenger boats, as they were not delayed by waiting for a full cargo, but sailed more or less to schedule time. Large and commodious vessels were built, practically all single screw, driven by reciprocating steam engines, of which the "Falcon" may be taken as typical. Built in 1876 by C. Mitchell and Co., of Newcastle, she had the following leading dimensions:—length, 200ft.; breadth, 27·2ft; depth, 14ft; tonnage, 675 gross. She was driven by compound engines, having cylinders 30in and 56in diameter, with a stroke of 33in., built by Thompson and Co., Newcastle. She only carried a very limited number of passengers and was mainly engaged on London-Ostend direct trade. Her nominal horsepower was 130.

Even though steel was destined to replace iron in ship construction and was applied to cargo steamers soon after "Falcon" appeared, iron ships continued to be built up to the beginning of the twentieth century, and just as the transition from wood to iron had been a gradual one, so steel only replaced iron by degrees. A notable steel steamer of earlier days was the "Hirondelle"—Fig. 2—an example of the larger cross-channel cargo

ship, which also carried a considerable number of passengers and was largely employed on the service between Harwich and Hamburg, with railway connections provided by the then Great Eastern Railway. She was built in 1890 by Gourlay Bros. and Co., of Dundee, who also provided the engines. Her principal dimensions were—length, 268ft; breadth, 37·5ft; depth, 16·5ft; tonnage, 1648 gross. She had triple-expansion engines with cylinders of 24in, 39in and 65in diameter respectively, and a stroke of 48in. Her boiler pressure was 170 lb per square inch, giving her a n.h.p. of 347. Steam was supplied by two single-ended boilers with corrugated furnaces with a grate area of 162 square feet and a heating surface of 1465 square feet.

The standard ship for this class of work for many years was the single-screw steamer, driven by reciprocating engines, with a limited passenger accommodation, but cargo increasingly taking the predominant place. For the services that still catered for a number of passengers twin screws were occasionally installed.

With the advent of the motorship a radical change took place, for this type of drive proved eminently suitable for the slower cargo vessels and in 1932 the small motorship, "Tern," of but 213 tons, joined the fleet of the General Steam Navigation Co. It seemed as if a good deal of coastwise and cross-channel traffic was likely to be filched by foreign competition, but the British companies had a fleet of about forty-five vessels, all steamers, whereas the current issue of Lloyd's Register shows forty vessels, of which no less than twenty-seven are motorships, ranging in tonnages from 2385 down to the 276 of the "Alouette." In both instances the pleasure steamers engaged on seasonal summer work are excluded.

Prior to 1939 there was an increasing tendency to cease to provide any passenger accommodation on boats of this class, while since the war the practice has been to build vessels exclusively for cargo work—a sad loss to the sea lover. This definite line of cleavage between passenger and cargo boats has been maintained from the early days of railways as steamship owners. Generally speaking, the cargo boat has been a handsome well-proportioned steamer, such as the one illustrated in Fig. 4. Then in 1939 the first railway oil-engined vessel appeared, on the Stranraer-Larne passage of the then L.M.S. Railway: the "Princess Victoria" was primarily intended for the conveyance of cars, but also had passenger accommodation. She was a war casualty, but has since been replaced by a ship of similar proportions and drive, bearing the same name. In 1947 appeared the first cargo motor vessel ordered by the Southern Railway, the "Winchester," a smart vessel with raked bows and cruiser stern. Her principal dimensions are—length, 241ft; breadth, 36·1ft; depth, 13·4ft; tonnage, 1149 gross. She is driven by two-stroke single-acting engines with ten cylinders, having a diameter of 18¾in and a stroke of 27$\frac{9}{16}$in. Her general performance will probably influence future policy, and we may see British Railways falling into line with the practice of private companies and concentrating on motorships for cargo carrying.

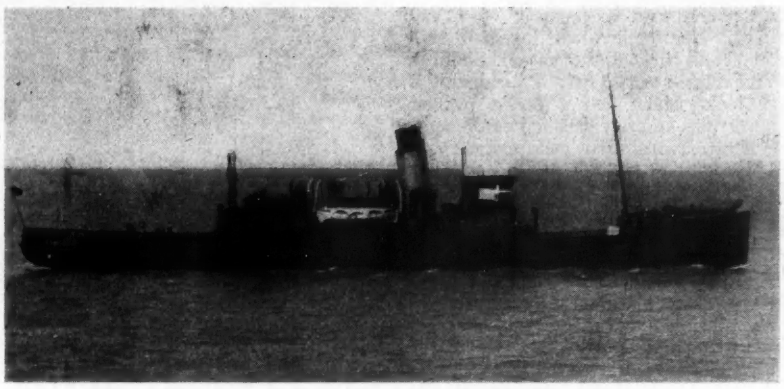


FIG. 4—SOUTHERN REGION CROSS-CHANNEL CARGO S.S. "HYTHE"

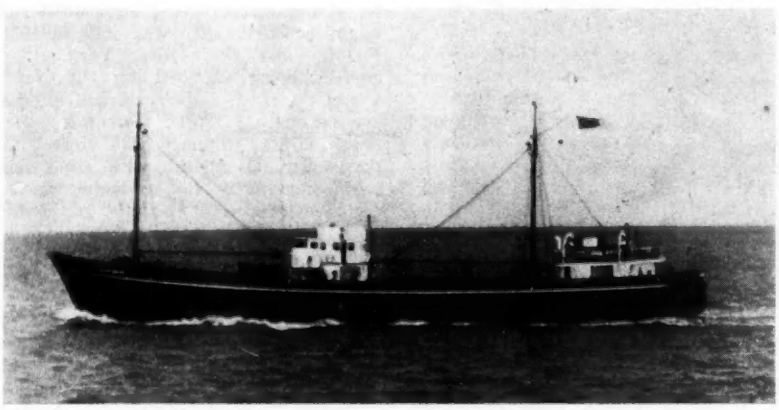


FIG. 3—M.V. "GREENFINCH"

engaged on this class of work wisely devoted much attention to building small craft, of which "Greenfinch" (392 tons) is a good example—Fig. 3—capable of going considerable distances up rivers and into shallow harbours. Forty years ago the average tonnage of cargo ships on one line was 1123 gross, compared with 963 of the present time, the decrease being largely due to the increasing number of useful little ships of 300 to 500 tons, although for services to the Mediterranean and places further afield bigger tonnage is still used. A good example of this is the motorship "Heron," of 2385 tons gross—a ship having a length of 302ft, a breadth of 45ft and a depth of 17ft. She is propelled by a Sulzer two-cycle S.A. four-cylinder engine of 1650 b.h.p., which gives her a service speed of 12½ knots. She was provided with accommodation for twelve passengers in four single and four double-berth cabins, which were very comfortably furnished.

As an indication of the way in which the motorship is gaining the ascendancy, it is of interest to note that a quarter of a century ago the General Steam Navigation Company,

It is not easy to select for description one particular modern cargo vessel, but the "Ptarmigan" has been chosen because the writer had an opportunity of crossing from London to Rotterdam on her. This being her normal duty, he saw for himself the facilities for loading and unloading, and was impressed by the smoothness of running, the comfortable quarters provided for the officers and crew, and the general efficiency of performance. She can be regarded as a typical medium-sized cross-channel cargo vessel. Built in 1948 by the Grangemouth Dockyard Company, she has the following dimensions—length, 224·3ft; breadth,

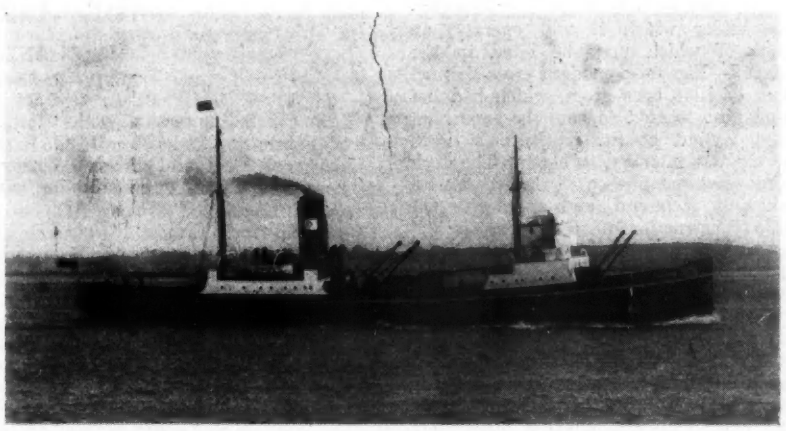


FIG. 5—S.S. "FALCON" SPECIALLY DESIGNED TO SUIT BERTHING CONDITIONS

36·2ft; depth, 11·7ft; tonnage, 959 gross She is driven by seven-cylinder British Polar Atlas oil engines, situated amidships, the cylinders having a diameter of 13⅜in and a stroke of 22 7/16in, and a b.h.p. of 1120, imparting to her a service speed of 11½ knots when fully loaded. She is fitted with five watertight bulkheads and has three T. and B. patent hatches with a capacity of 75,940 cubic feet. Her bunkers can take 101 tons of diesel oil and 10·75 tons of gas oil. Slanting bows and cruiser stern give "Ptarmigan" a modern look, which is not belied by her internal fittings and navigational equipment, for she is fitted with radar, echo sounder and Decca navigator, found on the spacious bridge. Immediately behind the wheelhouse, in which are the navigation instruments, a very comfortable self-contained suite is provided for the master. On the boat deck are the officers' quarters located round a pleasant and well-furnished recreation room, while on the shelter deck is an officers' commodious mess room, with hatch into a well-equipped cook's galley, cabins for pilot and cadets and quarters for the petty officers, the crew being catered for on the second deck, all the ship's company being accommodated amidships. There are two wooden lifeboats, each 24ft by 7·5ft by 3ft, fitted with motor and carrying twenty-six persons in each boat, and there is also a 14ft dinghy. As regards lifting appliances, two 2-ton electrically operated derricks are attached to the main mast and serve No. 3 hold, while Nos. 1 and 2 holds are catered for respectively by two 2-ton derricks on the front of the foremast and two 6-ton and one 1-ton derricks on the rear of the foremast.

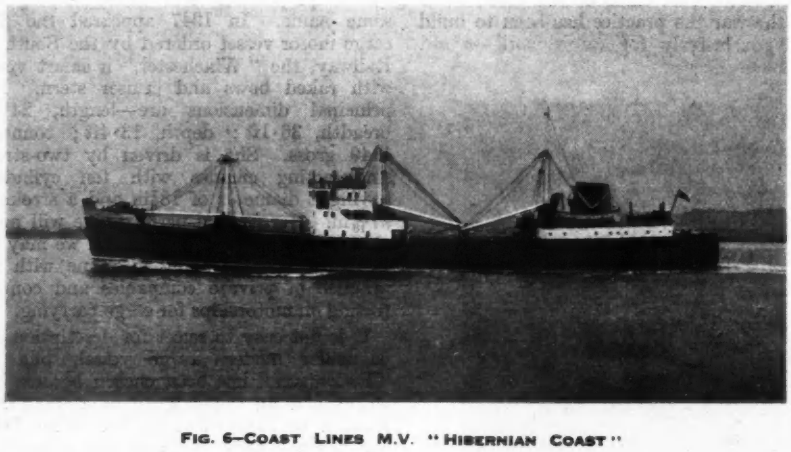


FIG. 6—COAST LINES M.V. "HIBERNIAN COAST"

It sometimes happens that the actual design of a vessel is influenced by the conditions under which it will operate, an instance of which may be cited in the "Falcon"—Fig. 5—a modern cross-channel steamer of 1038 tons gross, which had her hoisting gear located to suit the somewhat unusual lay-out at St. Katherine's dock, where she was intended to berth. The dock building came out flush with the wharf with openings at each end, and even with the suitable construction of the "Falcon" it was necessary for the ship to berth in an exact position between two marks for loading and unloading to be satisfactorily performed. In spite of the limitations quite a good-looking craft was produced.

Among cargo vessels of the sort under consideration, owned by private companies, in addition to those of the General Steam Navigation Company, already mentioned, Coast Lines, Ltd., maintains a large fleet of steam and motor vessels, "Hibernian Coast"—Fig. 6—being a good example. She was built in 1947 by Hall Russell and Co., Ltd., Aberdeen, and has the following dimensions:—Length, 265ft; breadth, 40·2ft; depth, 12·5ft; tonnage, 1258 gross. She is driven by British Polar two-stroke cycle, single-acting engines, with eight cylinders, of a diameter of 13⅜in by 22 7/16in stroke. F. T. Everard and Sons, Ltd., has built up a big fleet of shallow-draught vessels suitable for working to small ports and up-river destinations, thereby tending to counter competition from foreign owners. Apart from tankers, this one firm operates about fifty vessels, ranging from the "Ethel Everard," of 3539 tons gross, to the little "Will Everard," of but 188 tons. As an example of a handy little ship capable of entering small harbours, "Aridity"—Fig 7—might be cited. She was built in 1931 by Fellows and Co., Great Yarmouth, the engines being supplied by the Newbury Diesel Co., Ltd. Her principal dimensions are:—Length, 130ft; breadth, 24·6ft; depth, 8·9ft; tonnage, 336 gross. She is driven by oil engines with six cylinders, 9 7/16in diameter by 13 9/16in stroke, which give her a service speed of 8½ knots. In the ships of both these companies the same trend of development is noticeable, the transition from steam to the oil engine being very apparent, suggesting that for this class of work the days of the steam engine may be numbered.

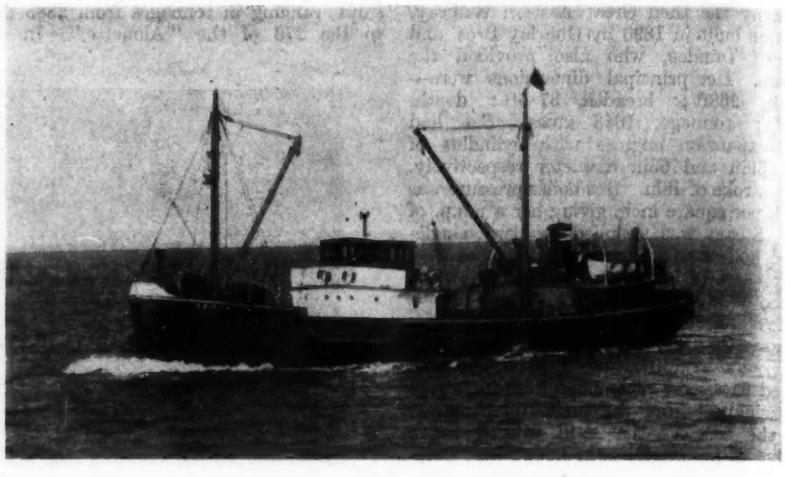


FIG. 7—M.V. "ARIDITY" SMALL EVERARD COASTER

A number of other lines owning cargo vessels might be mentioned, but it is hoped that enough has been said to give a general bird's eye view of how things have shaped and are shaping.

High Temperature Steels and Alloys for Gas Turbines

IRON AND STEEL INSTITUTE

No. IV—*(Continued from page 374, March 23rd)*

AT the concluding session on the afternoon of February 22nd, Mr. R. G. Voysey (Ministry of Fuel and Power), acting as rapporteur, introduced the following papers on "User Aspects" (Group II) and on "Research and Future Needs" (Group VIII).

MATERIALS AND PERFORMANCE

By A. T. BOWDEN and W. HRYNISZAK

An assessment is made of some of the effects on the performance of the industrial gas turbine resulting from the use of high-alloy steels, which are expensive as regards both first cost and fabrication. Consideration is given to the effect of using such materials upon the construction of the most essential components of the turbine, partly from experience gained with the Parsons experimental gas turbine. The choice of material is governed by gas temperature. Artificial cooling must be employed when it is desired to use materials of lower heat-resisting capacity to obtain about the same performance as that provided by higher-grade heat-resisting materials.

GAS TURBINE PERFORMANCE AND MATERIALS

By J. B. BUCHER

An indication is given of some of the more urgent metallurgical problems for which the industrial gas turbine designer awaits solution. The additional information desired includes creep data for periods of 10,000 hours and more at stresses between 2 tons and 6 tons per square inch, creep properties after cold working, further information on weldability and on the best methods of welding high-quality alloys, and a method of inhibiting vanadium attack. Mention is also made of the desirability of developing a comparatively cheap

steel with properties between present-day best ferritics and the cheapest austenitics.

INFLUENCE OF OPERATING TEMPERATURE ON THE DESIGN AND PERFORMANCE OF GAS TURBINES

By S. L. Bragg

Factors affecting efficiency are discussed, and it is shown that increasing the maximum operating temperature is the simplest method of obtaining worthwhile increases in both output and efficiency. In developing materials for turbine blading, the emphasis should be on obtaining the same strength at higher temperatures, whilst turbine disc material will require higher strength at the comparatively low hub temperature, without sacrifice of resistance to oxidation at the hotter rim.

STRESSES IN GAS TURBINE DISCS AND ROTORS

By R. W. Bailey

The nature of the operating stresses in "thin" and "thick" discs, and the resistance of ferritic and austenitic steels to bursting stresses, are discussed. For austenitic steel the importance of plastic strain in improving the properties at the central region of the disc or rotor, and thereby raising its bursting speed, is shown. The quality of the material at the interior of a disc or rotor must be proved if the highest working stresses are to be used safely.

RESEARCH AND DEVELOPMENT ON HIGH-TEMPERATURE MATERIALS

By C. A. Bristow and H. Sutton

Attention is drawn to the importance of availability in deciding on the constituent elements for high-temperature alloys. Metallurgical factors affecting the choice of metallic materials are discussed and are illustrated by various types of alloy. Long-range fundamental research is essential in providing the metallurgist with the necessary knowledge to enable him to devise and use high-temperature materials; and examples of such work are given.

FUTURE NEEDS IN MATERIALS FOR LAND AND MARINE GAS TURBINES

By J. M. Robertson

A general idea is given of the large range covered by the many types of land and marine gas turbines that are now being operated, constructed, designed or considered. Attention is given to the factors that are important in relation to the performance of materials in gas turbine components that operate at high temperatures, to the making, shaping and treating of these components and to their cost. A list is given of the classes of material now being used, and likely to be used in the near future, in the production of gas turbine components.

Dr. H. Roxbee Cox (Ministry of Fuel and Power), in opening the discussion, said that there was sometimes a tendency to criticise the gas turbine because it was expensive, and that it was expensive because it used expensive materials. He thought that this was unjustified. If expensive materials were needed to get greater gas turbine efficiency, it might be that expensive materials were the right things to use. He would like to see a breakdown of gas turbine costs as between blading, rotors, ducting, and so on, to give a better idea of where the money was going, so far as materials were concerned. With reference to vanadium attack, he would welcome an expression of opinion on another possible solution of the problem, and that was to indulge in slightly inefficient combustion. If combustion were incomplete, carbon in the exhaust itself had an inhibiting effect and was at least a partial preventive of vanadium attack. He had two questions to put to Dr. Bailey, who, he recalled, had done outstanding work on the important subject of disc stresses as the leading member of the Gas Turbine Collaboration Committee. These were, what would be the reaction on disc stresses of the additional temperature gradients introduced by cooling methods, and whether there were any particularly obnoxious temperature gradients which the cooling engineers should avoid; and whether there were any advantages from the point of view of thermal and other stresses in making discs of laminæ or plates gripped together. Referring to the last two papers, he asked for the authors' opinions on the prospects of being able to make use of ceramics and on the need for alloys intermediate in price and quality between the present ferritics and austenitics.

The Chairman (Mr. D. A. Oliver), supplementing the points raised by Dr. Roxbee Cox, put forward some questions for further discussion. It would, he said, be interesting to hear whether designers felt that all the effort should go into ferritic, rather than austenitic, disc material; how much users expected from such a technique as sweat-cooling; the pros and cons of welding or bolting together; what types of turbine had the greatest industrial future; and whether schemes for the immediate future envisaged the use of the best materials or whether the techniques of design had advanced so much that less efficient materials could be more cleverly incorporated in the engineering design.

Dr. C. Keller (Escher Wyss, Ltd., Switzerland) said his firm had concentrated on the closed-cycle gas turbine. They wanted it, in certain special cases, to replace the steam turbine and, at present, did not want to go above 650–700 deg. Cent. The first big plant, the 13 MW plant in Paris, would soon be running, and all the steels for the turbines, for the rotors and for the blades, had been supplied by English manufacturers. The Paris plant had taken a long time to construct, as it had been necessary to carry out so many tests first.

Mr. H. Capper (Admiralty) said the designer did not really know what level of properties he required for advanced designs of gas turbines, other than those in use at present. He would endorse Dr. Robertson's view that work to explore the distribution of stress in the various components would be of extreme value in connection with the use of the right material in the right place. In order to satisfy the desire of the metallurgist to know what were the future needs, the design section of the Engineer-in-Chief's department of the Admiralty had made a bold attempt to state those requirements for naval gas turbines. Help was thus given to the metallurgist in his difficult task of finding improved materials.

Dr. R. W. Bailey (Metropolitan-Vickers Electrical Company, Ltd.), in reply to Dr. Roxbee Cox, said that the severe thermal stresses in a disc occurred when the gas was turned on. The outside of the disc went into compression and only later changed over to tension. In the rotor, axial stresses were also brought in and greater care was needed. In the laminated disc there were compression stresses which would tend to hold the laminations together. He agreed with Dr. Bowden that prediction of behaviour for 100,000 hours based on tests for 10,000 hours did not mean anything, because it was essential to take into account thermal action on the material as well as creep action. In long-time tests he had always made temperature the accelerating factor and not stress. Dr. Bailey illustrated this principle by reference to the development of steels for steam turbines, and then applied it to gas turbine steels with the conclusion that an austenitic steel, showing advantage in a short life, might do no better than a ferritic steel when it came to a life of 100,000 hours. The difference between ferritic and austenitic steels was only a matter of about 30 deg. Cent. at 10,000 hours and not much cooling would be required to enable properly designed ferritic steel rotors to be used with complete security.

Dr. N. P. Allen (National Physical Laboratory) said that the engineer was too often governed by the idea that materials had stable properties, whereas the obvious solution of many problems was for the engineer to adapt his ideas to the properties of the materials. He agreed with Dr. Bailey that the very strong austenitic alloys had a tendency to lose their properties after a long time. Many troubles could be got rid of by careful attention to the cleaning of the turbine to make sure that products of corrosion did not accumulate. That meant designing the turbine from the beginning in such a way that it could be readily cleaned. He emphasised the need for systematic research, instancing the question of the brittleness of chromium. They had found at the N.P.L. that the brittle transition temperature of the purest iron could be brought down to −100 deg. Cent. or raised to 300 deg. Cent. by additions so small as not to be recognised in an ordinary analysis. If similar effects occurred with chromium, it might be possible to do something about the awkward problem of the brittleness of that metal.

Mr. W. Huber (Sulzer Bros., Ltd., Switzerland) thought that all gas turbines were too expensive, as was natural in a new development, and that any considerable raising of the gas temperature would bring about an increased price. The turbine blades for the Weinfelden plant were milled from bars, 87 per cent having to be machined away. Great possibilities were open in this field for precision casting. It had not yet been found possible to use heavy fuel oil in gas turbines, and the need for using more expensive fuel oil had restricted the field of application of gas turbines, especially for marine purposes. He was, at the moment, not asking for better materials, but was satisfied that large industrial or marine plants could now be run at 650 deg. Cent. for 100,000 hours.

Dr. J. S. Blair (Stewarts and Lloyds, Ltd.) made a plea for long-time tests. It was begging the question to extrapolate results on double-log.-papers. He could only recall one test that had ever been carried out for 100,000 hours, and one of 90,000 hours had been mentioned by Mr. Glen on the previous day. It was even now not too late to start. If it should be necessary to speed up the test, he agreed with Dr. Bailey that temperature was the variable to be increased.

Mr. S. T. Harrison (Armstrong Siddeley Motors, Ltd.) said that Dr. Bailey's analysis of stress distribution in discs seemed to imply that, after being run and allowed to cool, a disc should, if anything, shrink elastically in size; but his own experience was that discs in aero turbines invariably grew, often by 0·001in to 0·002in, but sometimes to an excessive amount, leading to fouling of the blade tips on the stator system. The growth usually took place fairly quickly and then slowed down; it was greater the higher the rim temperature, it was often associated with shallow radial cracks at the bottom of the serrations, and it was often different on the two sides of the disc, leading to bending of the blades. Mr. Harrison showed examples of failures which apparently conflicted with some of Dr. Bailey's views on stress distribution. The material of the discs was of high quality, and he had been impressed by the ductile appearance of test pieces taken from the fragments after the discs had burst. Trouble had been experienced from sulphur attack, especially in nickel-base alloy combustion chambers. Failure took place quickly when ash was deposited under reducing conditions and when the temperature was above about 630 deg. Cent., the melting point of the

nickel-nickel sulphide eutectic. Iron-base alloys were more resistant.

Mr. G. T. Harris (Wm. Jessop and Sons, Ltd.) said that more evidence would be required to establish Dr. Bailey's statement about the unreliability of austenitic discs compared with ferritic, as the number of failures of austenitic discs over the last several years had been exceedingly low—none in service, but all on the test bed. Those referred to by Mr. Harrison had taken place under abnormal stress and fierce acceleration. If a high standard of inspection were maintained there would be no great risk of engine failure.

Dr. N. Stephenson (National Gas Turbine Establishment) described experiments on attack by vanadium-containing fuel ash, intended to elucidate the mechanism of the action of V_2O_5 and also to indicate remedies. When combustion was inefficient there was some reduction in the amount of ash deposited. Certain additions brought about reduced attack; but, whether or not they proved economically successful, the most satisfactory solution would be the development of an alloy or coating which would resist that type of attack.

Mr. E. R. Robinson (General Electric Company, U.S.A.), at the invitation of the chairman, briefly described the organisation of A.S.T.M.-A.S.M.E. Joint Committee on the Effect of Temperature on the Properties of Metals. He referred to the difference in emphasis, in this country and in the U.S.A., placed on creep strength and on long-time rupture strength, and also to the present shortage of certain strategic materials.

Mr. H. W. G. Hignett (Mond Nickel Company, Ltd.) referred to "that fairy godmother of engineers, the factor of safety," and hoped that when it was used in high-temperature engineering it would not be applied to the rupture strength in a given time. After a material had entered the tertiary stage of creep it was no longer of any interest to designer or user. With reference to 100,000-hour tests, he thought it unlikely that designers eleven years hence would have any interest in materials which would be put under test to-day, and suggested that ten 10,000-hour tests had just ten times the value of one 100,000-hour test.

Dr. R. Graham (Shell Refining and Marketing Company, Ltd.) said that many of the data on vanadium attack had been based on laboratory experiments and very few on practical tests. The correlation between laboratory tests and actual combustion tests was qualitative only, and not constant from material to material. He did not feel hopeful that deliberate additions of further deposit-forming materials to the fuel would overcome the slightly obnoxious effects of vanadium.

Dr. A. T. Bowden (C. A. Parsons and Co., Ltd.), speaking of the cost of large industrial type gas turbines, said the cost of the blades was some 12 to 15 per cent of the total and of the spindles a like proportion. There was some difference in time and in amount of material used in the various methods of making turbine blades, but little difference in cost. He doubted the effectiveness of additions to fuel oil; distillation would, in the end, probably be cheaper.

Mr. J. B. Bucher (John Brown and Co., Ltd.) supported the demand for long-time creep curves. Even if the materials in use in eleven years' time were not the same as those which would be put under test to-day, an idea would be gained of how austenitic steels behaved after they had been in use 100,000 hours or more. On the question of costs, he said that the Sulzer plant, referred to by Mr. Huber, had an air heater and an open-cycle gas turbine. It therefore included the major difficulty of the open-cycle plant, with turbine blades subject to corrosion, and the main closed-cycle problem, that of an air heater; that might make the plant expensive. In inhibiting vanadium attack he had found no great improvement from inefficient combustion. Some cheap powders, such as chalk, would cut down the rate of attack considerably, but the most efficient additions were so expensive that it would be cheaper to use a distillate.

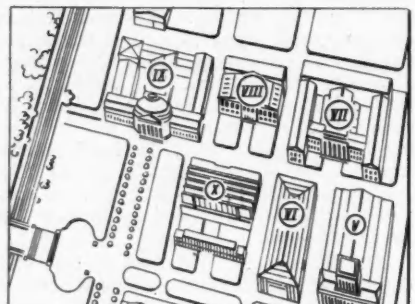
In bringing the session to a close the chairman thanked all those who had contributed to the success of the Symposium, and a vote of thanks to the chairman was proposed by Dr. Sykes.

The final report of the Symposium, which will contain written contributions as well as a full account of the discussion at this two-day meeting, is to be published as No. 43 in the Special Reports Series of the Iron and Steel Institute.

Leipzig Technical Fair

No. I

THE Leipzig Technical Fair, which opened on Sunday, March 4th, and ended on March 11th, was of special interest as it marked the first year of the five-year plan of the German Democratic Republic. At the opening ceremony in the Schauspielhaus the principal speaker was the Minister for Internal, External and Interzonal Trade, Herr Georg Handke, who stressed the need for co-operation between the Eastern and Western Zones, if difficulties of raw materials and trading were to be overcome. He also suggested that industrialists and workers in both zones should come together to settle differences.



I. Prime movers and general machinery.
II. German Democratic Government Pavilion.
III. Building materials and appliances, welding and foundry work.
IV. Road transport vehicles.
IVa. Woodworking machinery.
V. The Russian exhibit.
VI. Textile, leather and food-preparing machinery.
VII. Electrical machinery and appliances.
IX. Optical instruments, chemical exhibits and precision machinery.
X. Foreign collective exhibits.
Open-air exhibits: Agricultural machinery, railway equipment, building plant and road transport vehicles.

FIG. 1—ARRANGEMENT OF HALLS AT TECHNICAL FAIR

This year saw a further increase in the number of exhibitors, as is shown in the accompanying table. Fewer West German firms and people attended the Fair, owing to lack of special trains and difficulties with interzonal passes.

The general lay-out of the exhibition halls and the open spaces is shown in the drawing Fig. 1; it will be seen that Hall IV A has been added since last year. This hall was allotted to woodworking machinery. On the left hand of Hall VIII a new side aisle has been built, which gives accommodation for structural engineering exhibits. The open air spaces have been enlarged, to accommodate a wider range of machinery.

The Government Exhibit

This year, the German Democratic Republic, staged a special exhibit in Hall I, which was designed by DELWAG Werbung, of Berlin, to show how the industrial and political life of the Eastern Zone has developed. Some exhibits in Hall II were arranged to show the working out of original ideas. Among the machine tools seen in Hall I, one deserves special mention—the very large boring mill designed by the Vereinigung Volkseigenen Betrieb Werkzeugmaschinen und Werkzeuge (WMW), of Chemnitz, 31 Hofer Strasse 9. This machine is now approaching completion, and will shortly be erected in the shops of Bergmann und Borsig, of Berlin, where it will be used for the machining of steam turbine and generator parts. As shown in the illustration, Fig. 2, the machine differs from usual boring mill practice, in that the work is stationary, and the tool revolves on an arm carrying the toolbox. The total height of the machine is over 15½m and the table is designed to take work 10m in diameter, with a maximum height of 4½m. In addition to the main tool, the boring bar is provided with its own feed and speed control, which allows work 2800mm in depth to be machined. It will be noted that the table bed is extended beyond the machine, so that it can be traversed outwards, allowing the work to be lowered on to it by a crane. When fixed, the table is moved back under the machine and secured in its correct position by bolts and stops. The main tool drive consists of a 40kW motor, 200V to 380V, while a 12kW motor of the same voltage is provided for the auxiliary boring bar. The speed range of the main tool carrying arm is 0·1 to 2·80

Year	March, 1939	May, 1946	March, 1947	March, 1948	March, 1949	March, 1950	March, 1951
Area of Fair in square meters	198,211	26,355	57,688	86,137	102,000	132,000	145,000
Number of exhibitors	9,894	2,771	5,049	6,496	6,500	7,562	8,352
People's factory exhibits in square meters	—	—	5,342	16,239	33,000	54,426	70,000 (about)
Number of halls in Technical Fair	14	4	7	8	9	10	11

r.p.m. The drive from the motor is through two worm gears and pinions, which mesh with a large crown wheel 2000mm in diameter The arm can be raised and lowered and

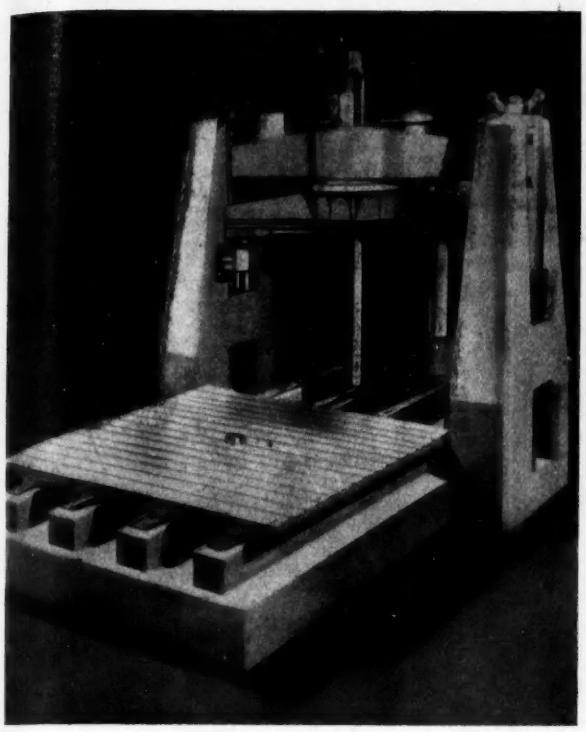


FIG. 2—NEW DESIGN OF LARGE BORING MILL—W.M.W.

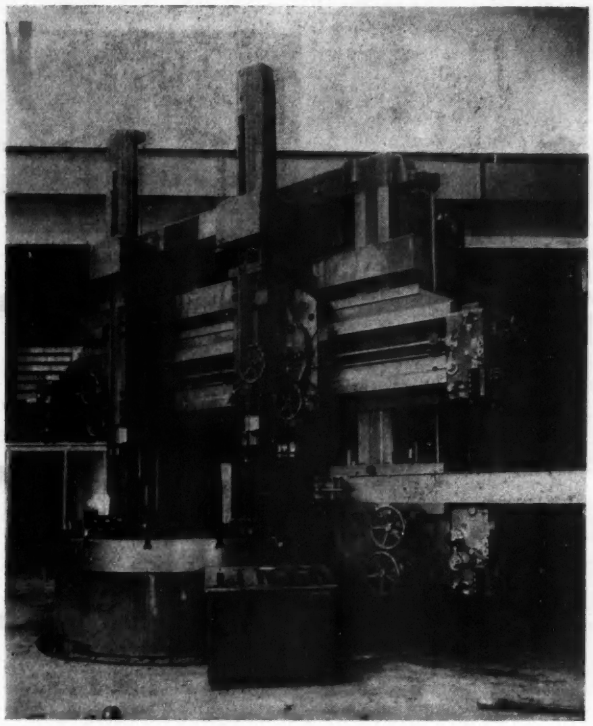


FIG. 3—LARGE VERTICAL BORING MILL—NILES-W.M.W.

automatically clamped on two side spindles. The boring bar has a speed range of 2·8 to 28 r.p.m., and all feeds are variable over a wide range. The electric controls for the whole machine are centralised in a desk with push-button control, which was shown

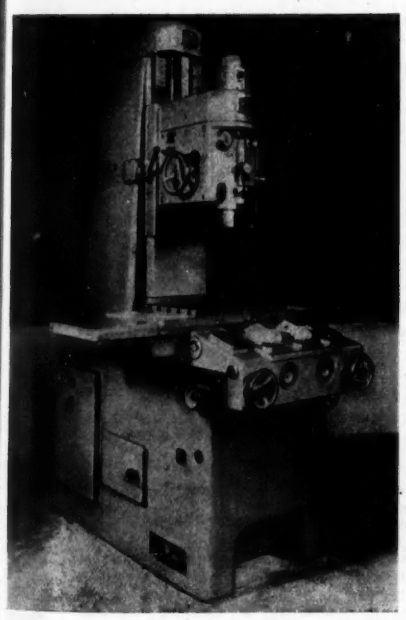


FIG. 4—VERTICAL JIG BORER—HILLE-W.M.W.

working a one-twelfth scale model in Hall I. To save time in making patterns and castings, a reinforced concrete construction was chosen for the main supporting members and the table bed. This construction, we are informed, enabled a saving of about 50 per cent to be made in the amounts of steel and cast iron needed, and there was a similar saving in the power of the driving motor. It was also possible with the new design to give a delivery of one year compared with at least two years for a normal design of boring mill with a rotating table.

MACHINE TOOL EXHIBITS IN HALL VIII

In general we noted a tendency towards the production of larger sizes of machine tools. Again the biggest exhibit was staged by WMW. One of the largest machine tools yet built in the Eastern Zone of Germany is the boring mill (by WMW Deutsche Niles Werke, VEB, Berlin-Weissensee, of Berlin-Weissensee), shown in the illustration Fig. 3, which indicates the general design of the machine and its control desk. The table is designed with a diameter of 3·500m for work up to 25 tons in weight. It is supported on large bearing surfaces which are oil lubricated and oil cooled. There is also a side tool support. The heads carrying the tools can each be swung to an angle of 30 deg., and all the movements are equipped with a wide range of feeds and speeds. The table has a speed range of from 0·7 to 28 r.p.m. All tool heads and side supports are clamped by electro-mechanical means. The main driving motor is a 48·7kW unit, which, together with the auxiliary motors for tool traverse and quick return, is operated from a desk equipped with push-button control. The weight of this machine is about 58 tons. We were interested to learn that work is well advanced on a similar boring mill with a table diameter of about 6m.

Another new machine was a vertical jig borer (B.L. 2 model) shown by WMW Hille Feinstmaschinenbau VEB, of Dresden, which is the first of its kind to be constructed in the Eastern Zone. The illustration Fig. 4 shows the stiff base which is well ribbed and the strong vertical support for the boring head. The table has coarse and fine controls for transverse and longitudinal movements, which are carried out by handwheels on the front of the table. The boring spindle has a range of speeds from 68 to 2800 r.p.m. The distance from the spindle head to the table is 530mm, and the usable table surface 450mm by 315mm. The optical measuring system, which was designed in conjunction with Carl Zeiss, VEB, of Jena, comprises glass scales read through microscopes. Fig. 5 shows the general arrange-

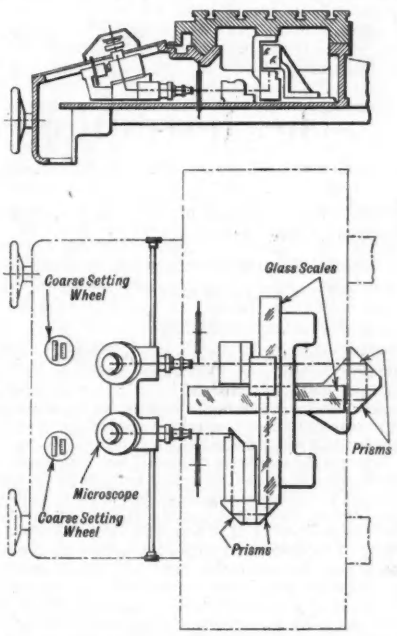


FIG. 5—OPTICAL MEASURING SYSTEM

ment of prisms and scales. By means of this optical arrangement it is possible to read with accuracy to $\pm^1/_{10}$mm, $\pm^1/_{100}$mm and $\pm^1/_{1000}$mm. The eyepieces are protected by light aluminium covers, in front of which

are the fine and coarse setting wheels. The scale lamp is placed in series with a time delay relay which extinguishes the light after twenty seconds and prevents undue heating of the glass scales.

For the grinding of large cutter heads such as are used on plano-milling machines, a new type of cutter grinder has been introduced by WMW. In this machine, which is illustrated in Fig. 6, the wheel to be ground is supported on a horizontal bed. This arrangement, it is claimed, enables the wheel to be checked for truth, better than with the usual vertical support. A small crane is provided to lift the cutter head on and off the support. The bed can be inclined to an angle of 90 deg. towards the grinding wheel, and 45 deg. away from it, which enables cutting clearance on the teeth to be ground. There are five grinding wheel speeds, giving a range of from 1225 to 4800 r.p.m. The machine is designed for grinding cutter heads with diameters of 110mm up to 700mm. It is built by the WMW Maschinenfabrik Berlin-Treptow VEB, of Berlin-Treptow.

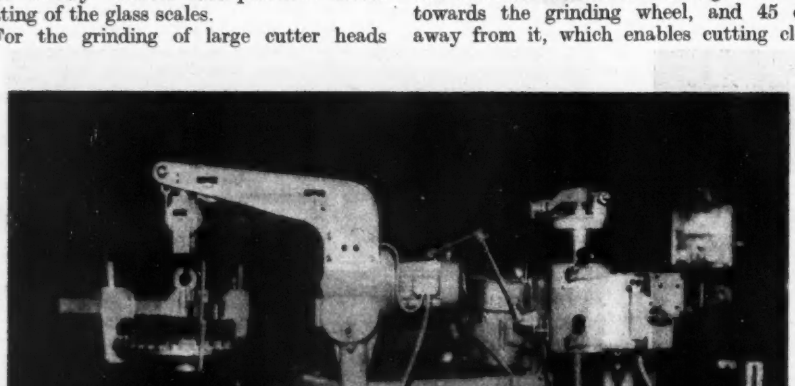


FIG. 6—CUTTER HEAD GRINDING MACHINE—W.M.W.

(To be continued)

The Institution of Naval Architects

No. III—(*Continued from page 389, March 23rd*)

THE first paper read on Thursday morning, March 15th, was :

THE SAFETY OF SMALL SHIPS

By H. E. SKINNER, O.B.E., B.Sc.

SUMMARY

The object of the paper is to test opinion as to whether or not the 1930 Load Line Convention work of increasing freeboards in small ships need be extended. A number of interesting facts emerge from the statistics of merchant ships lost given by Manley and these are noted.

When a ship rolls in waves, if her amplitude is small, she will roll with varying periods, but should she roll with a large amplitude her motion tends to have almost a constant period. Having established the decisive period of roll an idea of the amplitude likely to be associated with each period is given in the paper. Heavy weather motion is not sufficient to endanger a ship, but conditions may be made worse by a wave system tending to increase the heel, an adverse wind couple, and the shipping of water. The combined effect, if dynamic, will heel the ship to an angle which may be critical. There is also the possibility of adverse internal couples.

For a ship to withstand sea conditions she should always swing about the upright and be able to move through a large angle before immersing any dangerous openings. An empirical formula predicts the maximum angle of range, curves show the freeboard derived from stability considerations, and a table gives basic freeboard allowed to vessels of various lengths.

A typical static stability curve shows the effect of a timber deck cargo and particulars of a proposed design are given, together with the effect of the design on stability and tonnage measurement.

DISCUSSION

Mr. C. V. Manley said that losses of merchant ships reported abandoned, foundered or missing, were extremely low in relation to the total tonnage owned. Most of the casualties were small ships and were to one-deck ships. In two typical periods (1919–23 and 1934–38), one-deck ships represented about three-quarters of the total casualties, and an appreciable proportion of those were of the well-deck type ; the number of shelter or awning deck ships was relatively small.

A statement on stability circulated by the Ministry of Transport to the 1948 Safety Conference analysed twenty cargo ships, the losses of which were suspected as being due to lack of stability, and of the twenty cases, only seven were found to be primarily due to deficient stability. The records of abandoned, foundered or missing ships showed that the losses of those carrying wood cargo were fairly evenly divided between the summer and winter voyages, and did not follow the usual pattern in that respect.

Mr. Manley said Dr. Montgomerie's views agreed in many respects with those of Mr. Skinner ; but in regard to the subdivision of cargo ships, his conclusion was that a reasonable compromise had been reached between the claims of safety and those of economic operation.

Mr. H. E. Steel said that a very small ratio of casualties to small ships was due primarily to deficient stability, and commented on the statement that cargo shift was unlikely to be a basic cause of the loss of small ships in the fully loaded condition. There was no such thing as a small ship completely full of bulk cargo so that it could not shift. Mr. Steel quoted from a report which said that experience had shown that deficient stability was a less frequent primary cause of casualties than shifting of cargo, access of water or sluggish recovery from lurching or rolling through deficient freeing ports. Apart from a major influx of water, the entry of small quantities through air pipes and ventilators might affect stability adversely by free surface, by being confined on one side of the ship, by inducing a shift of bulk cargo or by causing choking of pump suction strums. The shifting of coal cargoes was a real problem and also cargoes of timber, smooth pig iron and certain chemical cargoes which became semi-fluid under the effect of movement and vibration.

Mr. Steel said that the stability of small mercantile ships was by no means a neglected subject, and that no less attention was given to the cargoes they carried and to their general seaworthiness.

Mr. W. J. G. Hawkins said that the author had drawn a stability curve and had laid down a criterion of stability, and had suggested that the static stability curve must have such an area as to indicate that the ship could withstand being hit by a wind of a certain pressure and the dynamic force of water on the lee side to 12in above the top of the bulwark. The author was aware that a number of small ships had not that criterion of stability under certain conditions of loading, and had concluded that they lacked stability and other seaworthy qualities. Mr. Hawkins went on to give two examples of casualties, which he suggested provided evidence contrary to the author's conclusions.

Good handling of a ship was required, and one could not take liberties with any ship, and certainly not small ones. It would not, he added, increase the safety of small ships to attempt to substitute, for the care which was necessary on the part of the master and officers, some design which on paper appeared to be proof against failure to exercise proper care.

He expressed surprise that a whale-catcher was included in the investigation into the stability of a small cargo ship, as its form was designed for quick manœuvring and for a speed of 14 or 15 knots.

Mr. Hawkins felt that the author's ultimate object was to achieve a design of ship which would give a sufficiently high freeboard/draught ratio to make it possible for the ship to possess a one-compartment standard of subdivision.

Mr. A. R. Mitchell said that for small ships of normal proportions the formula given for range of stability had been found to be most useful. But the majority of the small ships with which he was concerned were shallow draught vessels where the beam/draught ratio was often as much as 10 to 1, and he asked whether the author had available the value of coefficient "C" for vessels of that type.

He agreed that range of stability was much

more important than initial G.M., for many of the vessels started with a large G.M., but their range was limited, due to the maximum righting moment occurring at under 10 deg. heel at the point when either the deck edge was immersed or the bilge emerged. In some cases the range could be extended by fitting a superstructure, but nothing could prevent the bilge coming out.

Mr. D. W. Avey said that the author had neglected to consider any initial angular momentum a ship might have in the same direction as the elements, and had also omitted to take into account the reduced stability when the ship was on the crest of a wave. He imagined that with a sudden change in wave slope, the back wave slope must be deducted directly from the range thought to be on the ship.

He suggested that more attention be paid to increasing the stability of the ahead motion of ships in general, either by fining the outer body lines or by introducing extra stern trim, and said he had met cases where the trim was rather out of line with that way of thinking.

Mr. Skinner, replying to the discussion, commented on Mr. Manley's point in connection with the Ministry of Transport memorandum that the number of ships suspected of having been lost on account of instability was very small, and felt that the issue was prejudged. For example, if a ship had been heeling over to a large angle and in so doing had broken a ventilator and flooded, or if water had entered through a hatchway, it would have been said that the loss was not due primarily to instability, but to the fact that the hatch cover was not tight. Before it was accepted that the number of cases investigated represented the total of ships whose loss could be ascribed to instability, it must be made sure that there were not any ships which had been discounted.

Replying to Mr. Steel, he said that cargo shifting occurred just as much in large ships as in small ones, therefore the percentage loss of ships should not vary very much on that account, and he had dismissed that as a major factor.

Mr. Hawkins had rightly observed that no conclusion could be arrived at without careful and detailed investigation. With regard to the criticisms about the choice of a "whaler" for part of his investigations, he explained that the vessel was of whaler form, and was chosen because she had a very small freeboard/draught ratio and was very deeply loaded.

The next paper discussed on Thursday morning, March 15th, was :

FURTHER SHIP RESISTANCE SIMILARITY

By PROFESSOR E. V. TELFER, D.Sc., Ph.D.

(In the absence of Professor Telfer the paper was read by Dr. G. Hughes.)

SUMMARY

The experimental approach of William Froude to the study of frictional resistance has been made less empirical by the guidance of Reynolds law. The theoretical approach still depends upon experiment to determine its universal constants; therefore, experiment makes the final decision.

The basic principles of resistance similarity are re-examined and the basic similarity relation is given in a new form which results in an extension of the Froude law and states that all smooth geosims have the same total specific resistance at corresponding speeds and at corresponding viscosities. The extrapolator problem is considered and also the method of determining ship specific resistance at standard viscosity from data consisting of a series of Froude number contours to a base of corresponding viscosity.

The William Froude plank tests and their analysis are reviewed and earlier work on Gebers' plank tests is recalled. Froude's tests relating to surface finish are examined and also the length-depth ratio effect. A relationship is stated for specific resistance and this is developed into a complete formula to which is added a term to account for viscous roughness. Reference is made to Kempf's pontoon tests and the results are analysed and presented diagrammatically.

William Froude's method to extrapolate the results of his experiments to ship lengths are reviewed and examples show that, quite fortuitously, the Froude results refer to plated and not smooth ships. The data from Froude's rough plank tests are analysed and a simple formula established for roughness resistance.

The application of extrapolator principles to the problem of sand and viscous roughness is examined and linked with the question of seam and butt roughness. The Lackenby and Schoenherr formulæ for frictional resistance are critically examined and it is shown where they fail to respect the basis facts of experimental data.

The researches of the paper show that a lot of basic Froude methods are capable of rational development.

DISCUSSION

Dr. Hughes recalled that he had criticised severely the theoretical basis of Professor Telfer's 1949 paper, and as the basis of the present paper was the same he stood by his previous criticism.

An excellent part of the paper was that in which attention was drawn to the factors which made for dissimilarity in plank work, particularly the lack of geometrical similarity which was determined by the length-depth (L/D) ratio, and neglect of this feature had seriously obstructed efforts to obtain a proper view of the friction problem. Dr. Hughes did not agree that that effect could necessarily be represented in the way Professor Telfer had shown, but urged that one had to take account of it much more than previously. The effect had not been entirely neglected, but had been considered under the heading of "edge effect."

The paper referred to the possible adoption, at the forthcoming sixth International Conference of Ship Tank Superintendents in Washington next September, of a uniform means of transferring model results to the full size ship. It was hoped that this would be done, and the N.P.L. was endeavouring to produce new data over a wide range of Reynolds numbers; consideration was being given to the L/D ratio, and steps taken to deal with turbulent flow. Recently he had been engaged on a comprehensive analysis of existing plank work, and he believed that his conclusions would be found to be similar to those given in the paper, but had not necessarily found any evidence to support Professor Telfer's extrapolator formula.

Mr. W. C. S. Wigley commented on the number of papers concerning comparisons between model and ship results, and gave as the reason ignorance on the subject so far as scientific accuracy was concerned. Although near the truth, he did not think anyone could forecast the horsepower of a ship from tank experiments to an order of accuracy such as 1 per cent. By experience fairly accurate predictions were made, but that was not scientific measurement.

The first thing to do, since the laws which governed wave resistance similitude between ship and model in a perfect fluid were known, was to increase the power from the model to the ship by the ordinary conditions of similarity. That gave too much resistance, and William Froude had made an ingenious correction by assuming that he could make a correction on a model of a certain wetted surface which would be the same as the correction on a plank of the same wetted surface. That had brought the results much nearer, and in effect that was the method used to-day everywhere. It was now known that one could not separate the resistance of a model into the skin friction of the equivalent plank, plus the wave resistance of the model. There were at least three reasons for that: (1) the flow around a model was not the same as the flow around a plank, so that the skin friction of the model was not the same as on a plank of the same wetted surface; (2) the wave-making around the model affected the skin frictional resistance independently of the change in streamline flow of the model, due to two separate things—first, there was the difference between a model and a plank, due to the model's beam, and there was the change caused by the different velocities around the hull, due to the wave flow; (3) when the scale changed the wave motion was affected by the viscosity and it was affected differently, by the viscosity at different Reynolds numbers.

It seemed that Professor Telfer had some knowledge of that in his suggestion that several different sizes of model should be run in any particular condition; but supposing accurate measurements of the resistance were taken of five models of 4ft, 8ft, 12ft, 16ft and 20ft, the means to extrapolate were not known. Ordinary methods gave results within 10 per cent, but for scientific accuracy it would be necessary to know the real effects of the interference between the wave motion and the skin friction.

Mr. Wigley said he was sure the tank superintendent would not run six different models for every job; and the answer was to make tests on a number or full-size ships. The other method was the theoretical mathematical solution of flow in a viscous fluid which was tried in 1930.

The Chairman referred to the author's conclusion which mentioned the need for the adoption of a uniform means of transferring model results to the full-size ship, and recalled a remark made by William Froude to the effect that, in engineering, consistency of error was often more to be desired than absolute accuracy.

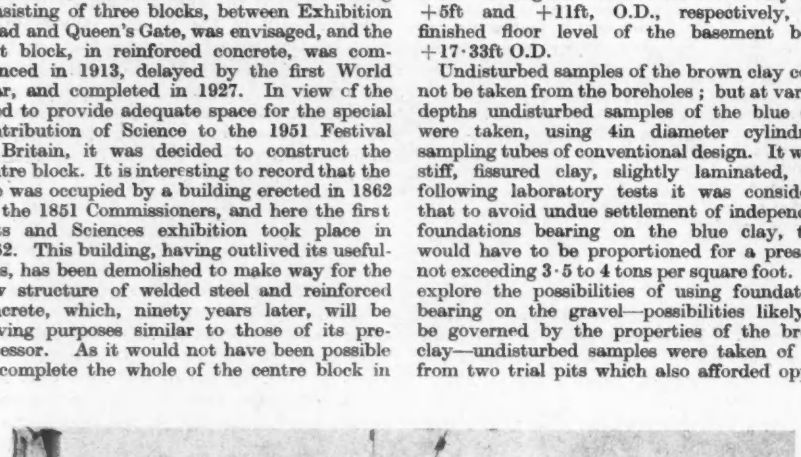
(*To be continued*)

Higher Technological Education

Among the subjects raised on the motion for the adjournment of the House of Commons on Thursday of last week was higher technological education, a debate on which was initiated by Mr. Ralph Morley. Much of the discussion dealt with the report on the future development of higher technological education, which was issued towards the end of last year by the National Advisory Council on Education for Industry and Commerce. Replying to questions asked during the debate, the Parliamentary Secretary to the Ministry of Education, Mr. Hardman, said that the Minister had not yet reached conclusions on the recommendations of the report. The Ministry of Education, however, would not delay a day longer than was necessary in making known its decisions, as it realised the importance of letting those engaged in higher technological education know what their future was to be. On one point, Mr. Hardman continued, he could be definite. Certain critics of the report had taken the line that all higher technological education could be carried out in the universities and that technical colleges should have little or nothing to do with it. That, Mr. Hardman said, was not the view of the majority of the universities. When it was held as a point of view it was, in his opinion, based upon ignorance of what in fact took place in the best technical colleges of the country. In certain quarters, Mr. Hardman thought, there could be a great deal of intellectual ignorance about technical education, which for too long had been the "Cinderella of the educational service." What he suggested had to be done was to work for developments both in universities and technical colleges, not in any competitive spirit, but to meet the needs of both, and in so doing to meet the needs of the nation.

Extension of the Science Museum

THE Science Museum at South Kensington, London, was founded in 1912. A building consisting of three blocks, between Exhibition Road and Queen's Gate, was envisaged, and the east block, in reinforced concrete, was commenced in 1913, delayed by the first World War, and completed in 1927. In view of the need to provide adequate space for the special contribution of Science to the 1951 Festival of Britain, it was decided to construct the centre block. It is interesting to record that the site was occupied by a building erected in 1862 by the 1851 Commissioners, and here the first Arts and Sciences exhibition took place in 1862. This building, having outlived its usefulness, has been demolished to make way for the new structure of welded steel and reinforced concrete, which, ninety years later, will be serving purposes similar to those of its predecessor. As it would not have been possible to complete the whole of the centre block in time for the Festival the present construction is confined to the basement, ground and first floor, with a temporary roof over the central well. The final decisions have yet to be made regarding the arrangement of exhibits in the centre block when it is fully completed. It is likely that transport, communications and astronomy will be exhibited, however, with a planetarium (the first in Great Britain) on the third floor.



CONSTRUCTION OF RAFT FOUNDATIONS

The centre block is approximately 400ft long by 100ft wide, and on completion its five storeys will reach to a height of about 100ft above the basement. Escalators will be provided to enable visitors to reach all sections of the building.

Sub-Structure

The geological formation of the neighbourhood was known to include a layer of flood plain gravel of the Pleistocene period, overlying London clay of the Eocene period. Records of well borings show that in the vicinity the London clay extends to a depth as great as 270ft. The surface of the site was fairly level at about +28ft O.D. Boreholes indicated that the top 3ft to 6ft of filling, maiden soil, and gravelly clay was lying on a gravel deposit 12ft to 18ft thick, below which was a stratum of brown clay 1ft to 2·5ft thick; the blue clay persisted throughout the lower depths of all boreholes. The ground water table was approximately in the middle of the gravel layer at +11·5ft to +16·5ft, O.D., and the lowest and highest levels of the brown clay were +5ft and +11ft, O.D., respectively, the finished floor level of the basement being +17·33ft O.D.

Undisturbed samples of the brown clay could not be taken from the boreholes; but at various depths undisturbed samples of the blue clay were taken, using 4in diameter cylindrical sampling tubes of conventional design. It was a stiff, fissured clay, slightly laminated, and following laboratory tests it was considered that to avoid undue settlement of independent foundations bearing on the blue clay, they would have to be proportioned for a pressure not exceeding 3·5 to 4 tons per square foot. To explore the possibilities of using foundations bearing on the gravel—possibilities likely to be governed by the properties of the brown clay—undisturbed samples were taken of this from two trial pits which also afforded opportunity to see the gravel in position and judge its bearing capacity and the degree of trouble likely to be experienced during excavation. Information was also obtained regarding the rate of flow of the subsoil water.

Tests on the samples of brown clay showed it to be fairly stiff, slightly fissured and, of course, weaker than the blue, its average cohesion value being only half that of the blue clay. For independent foundations on the gravel it was estimated that the bearing pressure should not exceed 2·5 tons per square foot. The boreholes and trial pits showed that the surface of the clay appeared to be falling towards the River Thames, 1 mile distant. Later, during excavation, a marked difference of water level was obtained each side of a line running diagonally across the site and roughly parallel to the river, a difference attributed to a ridge or bank of clay acting as a dam. Samples taken from the gravel showed a very small percentage of fine sand, indicating that there should be little danger of settlement occurring in the event of dewatering. Tests on the subsoil water showed it to be very slightly alkaline, but that the soluble sulphates, estimated as 0·02 per cent, equivalent sulphur trioxide, should have no deleterious effects on concrete.

To accommodate the basement, bulk excavation was necessary for a depth of at least 13ft. It was estimated that pier foundations carried down to the blue clay would have been the cheapest form, had there been no likelihood of trouble from the high rate of flow of subsoil water. Even with a wellpoint system to lower the water table, the shortage of timber and skilled timbermen would undoubtedly have affected the target date for completion. The time factor was also held to rule out the use of long steel sheet piling, around individual foundations.

A raft foundation bearing on the gravel offered several advantages. The water table would require lowering only a few feet, over half the area; practically all the excavation could be done by machine; the pressure on the brown clay below the gravel would be fairly uniform, and little more than the existing pressure, and work at the east end would be simplified because excavation would not extend below the foundations of the existing Science Museum. The basement could be securely tanked by a waterproof membrane on the outside of the raft and retaining walls, and completion within the allotted time could be safely reckoned upon. It was accordingly decided to employ a raft foundation.

The raft was designed with a maximum thickness of 3ft, but to accommodate service pipes large areas between the rows of stanchion were reduced to 18in thick, thus forming an inverted slab and beam construction. The top of the raft was kept 12in below the basement level to accommodate small branch ducts leading to the stanchion positions (for rising services) and to provide depth for the stanchion bases. Crossing the site at a level below the general line of the raft a cable subway was constructed 10ft wide by 7ft high. The subway was designed as an integral part of the raft, to a shape which avoided an abrupt change of section and required no timbering during excavation. Along the north and south sides the raft is forward of the building line to reduce the pressure under the edge and to accommodate a longitudinal duct. The retaining walls are integral with the edges of the raft. The concrete mix specified for the raft was 1–2–4, and the working stresses 1000 lb per square inch for compression due to bending, and 100 lb per square inch for shear. The reinforcement, m.s. bars up to 1¼in diameter, had a working stress of 18,000 lb per square inch.

In order to speed up excavation, steel sheet piling was used to retain the earth outside the construction lines. Wherever possible, the height of retention was reduced by sloping the surface of the cut. A 3in thickness of plain concrete was laid on the gravel immediately after final excavation, and asphalt applied to it in three layers, followed by a protection of 2in of plain concrete on which the raft reinforcement was assembled. The retaining walls were cast against asphalt applied to a wall of 4in concrete blocks built against the sheet piling. Construction of the raft may be seen in progress in the accompanying illustration. A batch mixing plant and concrete pump were used in the construction of the raft and retaining walls. Concrete was pumped for a distance of 400ft at the rate of 80 to 90 cubic yards per day.

Superstructure

To provide for the varied nature of Science Museum exhibits, ranging from heavy machinery to delicate mechanisms, the floor panels were required to be stiff in both directions and such that holes of reasonable size could be cut later without detrimental effect. Cast-in-place slabs of solid reinforced concrete were selected as best fulfilling these requirements.

Copper pipes were embedded in the soffits of the floor slabs as part of the space heating system. They were laid on the shuttering in hairpin panels and connected to flow and return pipes at the stanchions. Clay tiles, thicker than the pipe diameter, were laid between the loops to protect them during the placing of reinforcement. A further stipulation required that electric power, gas and compressed air should be readily available at any position in the display areas. This was met by sinking the floor slab to form service ducts from which at any time the required supply can be run in the depth of the batten under the floor boards.

As the ground floor will have to carry heavy exhibits, the design provides for a superimposed

load of 336 lb per square foot on the slab panels and 280 lb per square foot on the beams. The upper floor allowances vary from 112 lb to 168 lb per square foot, according to use. To minimise the effect of thermal movement, the centre block superstructure is divided into sections and divorced from the east block.

Structural steelwork was selected for the main framing as it ensured completion within the target date and could be readily modified, if necessary, to suit the needs of the Festival. Mild steel was used throughout, for although high-tensile steel would have shown a marked economy in certain members, it could not be promised in time. Certain features of the centre block tend to reduce its lateral rigidity. The storey heights are considerable and have few cross walls, whilst the first and second floors are perforated by a large open well. In order to give adequate stiffness, an all-welded rigid frame was considered; but as this would have required more time to design and build than was available, a semi-rigid design was adopted, providing for the use of tight-fitting bolts in the beam to stanchion connections. Additional stiffness was given to the middle section by introducing end walls of reinforced concrete to form abutments to any lateral forces communicated to the floors.

All compound beams and plate girders were specified to be of welded construction, and consideration was also given to the employment of welding for the stanchions, which carry loads up to 650 tons, with a storey height from ground to first floor of 23ft. The cost of various riveted and welded sections was compared and an all-welded box section was finally adopted, composed of two plates and either two or four channels, with thick plate seatings for the beams, and U-shaped connectors for picking up the top cleat bolts. The stanchions are shown in the accompanying illustration.

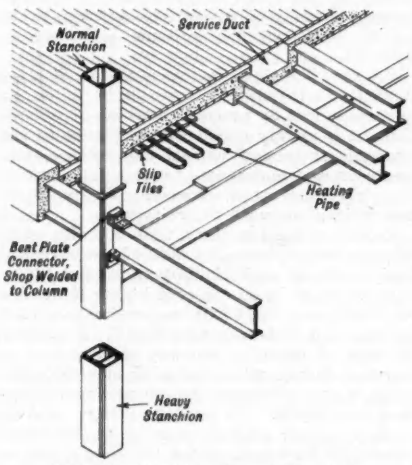
It was considered that this form of stanchion had several advantages. The high section modulus obtained on each axis gave end restraint to the floor beams. It was found that an axial load of 460 tons on an effective height of 18ft required a box section weighing 236 lb per foot, or a compound I-section of similar overall dimensions weighing, with rivet heads, 259 lb per foot, a saving, in this particular example, of 9 per cent. Also, an advantageous increase of the channel area could be obtained by opening the rolls to give a thicker web. This was done for many of the stanchions, and caused no delay in deliveries. The bracket and top cleat detail is common for all beams in this case, whereas with an I-stanchion, eccentric beams connecting to the web frequently entail special brackets, stiffeners, and side notching. The usual trouble with deep beams framing into the webs of I-stanchions does not occur with the box, for all beams are placed in position by swinging horizontally.

Handling time in the work is reduced with this form of stanchion, because the main material of the shaft requires no drilling, this being confined to the fittings which are welded on. The channels and diaphragms, pre-assembled, form a stiff core to which the flange plates can be readily clamped, so there is no need for an elaborate assembly jig. Stanchion joints are simple and can easily be made to accommodate the stresses. A joint plate is attached to the end of the lower shaft by fillet welds around the profile and the upper shaft is secured by long temporary bolts in service cleats (for the completion of beam erection and plumbing), and is then fillet welded around the profile. The joint need be no higher than the floor level, so that the lower shaft, usually larger than the one above, does not protrude into the upper storey and entail the larger casing, as occurs with the more usual spliced joints. When concrete casing is required, it is confined to the minimum thickness on all four sides of the box, thus using less concrete than the I-section. For a box stanchion which is to be left uncased, the area to be painted is less than with an equivalent I-section, and the internal surfaces need no painting for the box is fully sealed by the seam welds and end plates.

Although all these advantages were found when using the box-section stanchion, it was also discovered that erectors might regard them unfavourably, because they cannot be so readily climbed as an I-section. This disadvantage could, it was thought, be overcome by providing hook ladders of suitable design.

Welding

Where the flange plates of compound beams changed section the lengths were butt welded together before being tack welded to the I-section. The compound was mounted in a manipulator and the longitudinal fillet welds made in the downhand position by two welders working simultaneously from the centre to the ends. No distortion troubles were experienced and the longitudinal shrinkage was negligible, as few of the compound beams exceeded 25ft in length. The joints of plate girder flange plates were also butt welded as the first operation. All parts of the girder were then assembled, tack welded together, and mounted in a manipulator. Stiffeners and fittings were first welded to the web in the horizontal-vertical position, followed by the main longitudinal fillet welds which were run downhand by two welders working simultaneously from the centre to the ends. Lastly, stiffeners were welded to the flange plates in the horizontal-vertical position. Distortion troubles were minor and longitudinal shrinkage negligible, though here again the girders were comparatively short.



STEELWORK AND FLOOR DETAILS

In the case of the two-channel type of stanchion, as a first precaution, extreme care was taken to ensure that all shaft material was straight and free from wind. The two channels, with accurately profiled diaphragms welded in between, were checked for straightness and rectified where necessary. The flange plates were tack welded to this unit which was then mounted in a manipulator by means of which the main longitudinal fillets were run downhand by two welders working simultaneously from the centre to the ends. Little trouble was experienced with distortion provided the material was dead straight and free from wind before welding. The longitudinal shrinkage in 36ft was about $\frac{1}{4}$in.

Difficulty was experienced in the initial stages with the four-channel type of stanchion. Three of the first four shafts completed had a wind of up to $\frac{3}{4}$in in the length. The trouble was satisfactorily overcome, however, by a rigid adherence to the procedure outlined below.

Prior to assembly, all shaft material was carefully straightened and where necessary corrected for wind. The two centre channels were assembled and connected together by welded plate diaphragms, accurately machined to size. Flange plates, after butt welding different sizes together, were preset $\frac{1}{16}$in in the width to provide for subsequent shrinkage from the longitudinal welds. The flange plates were then carefully positioned on the centre two-channel component and secured by tack welding. This component was then mounted in a manipulator and the longitudinal welds made in the horizontal-vertical position by four welders working simultaneously from the centre to the ends. The two outer channels were then inserted, care being taken to ensure they were correctly positioned at all points throughout the length, as errors in this appeared to be the cause of wind in the finished shaft. With the outer channels tack welded in position the shaft was remounted in the manipulator, and the longitudinal fillet welds made in the h.v. position by four welders working simultaneously from the centre to the ends.

With both types of stanchion, all bracket plates and top cleat connectors were welded on with the shaft still in the manipulator so that the principal welds could be conveniently made in the downhand position. The stanchions were then machined to exact length and fitted with end plates.

Erection

The total weight of steelwork in the centre block, up to the first floor, was 1000 tons, the whole of which was erected by two guy derricks. Steel slab stanchion bases were set on packing plates to fairly close position and level before the stanchions were erected. Small plates, welded to the stanchions in the works, were site bolted to the slabs, which was found to be a far more convenient arrangement than shop welding the slab. On completion of erection, lining and plumbing, the 2in space between the raft and the slab was packed hard with a moist cement and sand mortar.

Construction of the beam and stanchion casings and floor panels followed closely on the steelwork erectors. Access to the site was extremely poor, for it is hemmed in by existing buildings. A ready co-operation between all concerned, however, helped to get round this difficulty and complete the work within the target date. For occupation during the Festival of Britain, the open well has been temporarily roofed over at first floor level by ordinary trusses and corrugated asbestos-cement sheeting. The shoe connections were specially arranged to allow the upper floors to be completed without disturbing the temporary roof.

The consulting engineers for the foundations, steel frame and reinforced concrete of the building described above, were Husband and Co., in collaboration with Mr. G. A. Gardner, O.B.E., Chief Structural Engineer, Ministry of Works. The architect was Mr. W. Wendall (Ministry of Works), the general contractors were Higgs and Hill, Ltd., and the steelwork contractors Moreland Hayne and Co., Ltd.

Liverpool Steam Ship Owners Association

The report of the Liverpool Steam Ship Owners' Association for 1950, which was issued last week, surveys the overseas trade position and states that costs of production will be further increased owing to devaluation. The end of financial aid from America means that the standard of living must be that which is earned, and the failure of the coal industry to provide sufficient coal for export is classed as a national disservice. War losses, the report continues, have been almost made good, but only by the inclusion of war-built vessels, which have a high rate of depreciation and therefore require to be replaced at an early age. The renewal of the "stopgap" and older tonnage will need to be undertaken during the next decade, and this task is imperilled by the present taxation assessment, which is denuding the liner companies of the essential funds. In the report it is emphasised that war loss compensation took no account of the actual replacement cost, and it is suggested that for renewing a fleet earnings must exceed current needs and profit for taxation purposes should only be assessed after providing for tonnage replacement. The Association points out that the present basis of assessment for taxation includes that part of the profits which must be retained in the business, and asserts that, in a few years, persistence in this method of assessment will cause a gradual reduction in our merchant fleet. Among the many other points raised in the report is the waste of carrying capacity caused by bulk buying.

Survey of Existing Railway Electrification Systems*

THERE are three basic electrical systems suited to railway traction: direct current, alternating current single-phase, alternating current three-phase.

The extent to which these systems of electrification are in use throughout the world is shown in Table I:

TABLE I—*Approximate Mileage of Railway Electrification in All Countries on Differing Systems and Voltages*

Direct current						Alternating current			
Low voltage		Higher voltage				Single-phase low-frequency		Three-phase	
600V to 800V		1200V to 1500V		3000V		Various voltages		3700V and 5500V	
Route	Single track	Route	Single track	Route	Single track	Route	Single track	Route	Single track
1300	3300	5000	9400	5200	9200	9800	18800	1000	1600

Note.—Mileages exclude those of urban systems such as London Transport and associated lines, underground and elevated lines in New York, Chicago, Paris, Berlin, Moscow, &c.

It will be seen that the extent of electrification on low voltage with direct current and on three-phase alternating current is comparatively small. The mileage of electrification using higher-voltage direct current is approximately the same as for single-phase alternating current.

D.C. SYSTEMS

In the early days of d.c. electric traction the source of power was a special generating station supplying direct current at a low voltage exclusively for traction purposes; industrial and domestic supplies were generated at about 440V direct current at separate power stations. With the development of the a.c. system of public supply, the special d.c. generating station for electric railways was gradually superseded by substations equipped with converting plant, taking three-phase power from railway-owned a.c. generating stations and delivering direct current to the trains at the desired voltage. Even so, these power stations were designed to generate at low frequency solely for railway purposes; it was not then practicable to construct rotary convertors to transform alternating current at the normal industrial frequency to direct current.

With improvements in the design of rotary convertors, a.c. low-frequency generating stations were not constructed for new railway electrification schemes, and power was taken at normal frequency from the general supply system of the district or the national grid. More recently, mercury-arc rectifiers have taken the place of rotary convertors for all new schemes of railway electrification on the d.c. system. Provided such plant is suitably designed, disturbances to telecommunication circuits need not be apprehended.

Spacing of Substations.—Rectifiers of given capacity are rather cheaper the higher the distribution voltage, but the difference is small in relation to the total cost of the substation. On all electrified lines, except those on which the effects of faults, and the provision of spare plant; no hard and fast rule can be applied. Average spacing of substations on some existing or projected d.c. systems is shown in Table II.

TABLE II—*Examples of Spacing of Substations for Direct Current Systems*

Country	Electrification	Average substation spacing, miles
	650V to 750V:	
England ...	Southern Region	3½
	London Transport	1½ (central)
		2¼ (outer)
	1500V:	
India	Great Indian Peninsular Railway	12
France... ...	Paris, Le Mans	11
United States	Illinois Central Railroad ...	6
England ...	Manchester, Sheffield, Wath	5
England ...	Liverpool Street, Shenfield	4¼
	3000V:	
United States	Chicago, Milwaukee, St. Paul and Pacific Railroad	30
South Africa	Natal	15
United States	Delaware, Lackawanna and Western Railroad	12

Effects of Voltage on the Cost of Rolling Stock.—While the distribution voltage may be influenced to some extent by practical working considerations, it is mainly decided by reference to the economic factors of capital expenditure, and operation and maintenance costs. The cost of electric rolling stock, especially for multiple-unit trains, rises with the voltage.

Recent estimates show that for the same average performance the cost of the electrical equipments of multiple-unit trains for 1500V is approximately 10 per cent higher than that for 750V, and for 3000V approximately 17·5 per cent higher than that for 1500V. For 3000V the cost of large locomotives of 2500 h.p. or more, including all mechanical and electrical parts, is approximately 10 per cent more than that for 1500V. As explained later, special flywheel motor generators have to be incorporated in locomotives for 750V in order to maintain tractive effort over gaps in the conductor rail, and for this reason the locomotives are expensive.

As regards the general design of motor coaches, there are advantages in simplicity of electrical equipment for the lower voltages, but for main line locomotives there is no material difference in this respect. Between low and high voltage there is little difference in the cost of maintenance of rolling stock, but probably the low voltage has a slight advantage.

The D.C. Traction Motor.—The modern d.c. traction motor has reached a very high standard of reliability, and, with a range of field tapping or field shunting, a number of economical running speeds can be obtained. On the low-voltage system, the control gear and auxiliary machines are nowadays suspended from the underframe of the coach. On higher-voltage systems they are sometimes carried in a special compartment in the coach. This, however, is not essential, as the whole equipment, except the master controller, switches and instruments required in the driving compartment, can be suspended from the coach underframe.

Motors of the nose-suspended type for the 3000V system multiple-unit trains require more space than motors for similar performance on 750V or 1500V systems, and this may influence the height of the coach floor from rail. Small motors for either 750V or 1500V systems can be mounted on 36in wheels, with a minimum floor height of 41in. On the 3000V system motors require at least 39in or 40in wheels, with a corresponding increase of 3in to 4in in the height of the coach floor. This difference in floor height is a factor to be kept in mind in any development of double-deck coaches for suburban traffic.

Comparison of Overhead Line and Conductor Rail Systems.—Electrical energy is distributed from the substations to the trains on the low-voltage system by high-conductivity steel rails on insulators fastened to the sleepers or, for the higher-voltage systems, by wires suspended above the track. Other things being equal, the choice between the two methods depends on the distribution voltage.

Conductor rails are not normally used for voltages above 750, and in this country there is only one line, the Manchester–Bury line, with a voltage as high as 1200, where the special structure gauge enables a protected conductor rail to be installed. While this, and similar methods which are available, give protection to railway staff and others against the risk of contact with a live rail, the limitations generally imposed by the load and structure gauges of British Railways do not permit of their extended use. For the higher voltages, therefore, overhead conductors are inevitable.

The overhead electrical equipment for 3000V or 1500V takes the form of a copper or copper-alloy contact wire suspended over the track from a copper catenary wire. The wires are generally supported on steel structures with concrete foundations spaced 220ft apart or less, the actual distance depending on the curvature of the line.

No restrictions are imposed on maintenance of way and works by the overhead equipment, except for painting and other work closely adjacent to the conductor wire, which must be carried out only when the lines are dead. There is little difference in the costs of maintenance of 1500V and 3000V overhead lines, which are approximately 70 per cent higher than for the single low-voltage conductor rail. The first cost of the overhead line is higher than that of the conductor rail, but expenditure on improved line-side fencing, which may be essential in many places with an unprotected conductor rail installation, must be taken into account.

The overhead line is not appreciably affected by ice. Interruptions to traffic occasionally occur due to icing of conductor rail, but experiments with de-icing methods have already met with a large measure of success.

Both overhead lines and conductor rails are liable to suffer damage from accidents and derailments, but experience has proved that they can usually be restored for traffic in no longer time than is required to clear and make good the running tracks.

The important questions of electrolysis and interference with communication circuits arising from the use of d.c. systems are discussed in Chapter XV and in the Appendix to the Report.

Locomotives for Conductor Rail Operation.—With the overhead line the supply of electrical energy to the train is available at all points: with the conductor rail the continuity is interrupted by gaps at crossings and junctions in the track. Multiple-unit trains, however, are either fitted with power-bus-lines connecting the current-collector shoes throughout the train, or the motor coaches are so spaced that there is always at least one in contact with the conductor rail. An electric locomotive is of insufficient length to bridge all the gaps in a conductor rail system; nevertheless, the tractive effort can be maintained by the use, within the locomotive, of motor generators fitted with flywheels, so that stored kinetic energy is available for maintaining tractive effort when moving over gaps, or for restart after stopping for a limited time on a gap. Such locomotives, while capable of giving satisfactory service, are more expensive and less efficient electrically than those generally used with overhead lines.

The system used on the Metropolitan section of London Transport whereby train sets fitted with through power-bus-lines and collector shoes are hauled by electric locomotives would not generally be suitable for main line working as it would be impracticable to fit all main line carriages and wagons to carry the bus-lines and collector shoes.

Sighting of Signals.—It is important both from the point of view of safety and operating efficiency that the drivers' approach view of signals should be unimpeded, and with overhead electrification the sighting of semaphore signals from the cab of a locomotive or multiple-unit

* Abstracted from Report on "Electrification of Railways." British Transport Commission, 1951. Price 7s. 6d

train may be impaired by the overhead line structures. Whilst on some electrified railways little alteration to signals has been found necessary, there are many places in this country where on account of close working through short block sections, or of high running speeds, interference with the continuity of sighting could not be countenanced. It would be necessary, therefore, in the absence of full colour-light signalling, to provide intensified light signals on some sections of the line in place of many, if not all, existing semaphore signals. Track circuiting is not essential for the operation of these signals.

A.C. Single-Phase System

This system, in its widest application in Europe and the United States, is in some ways similar to the d.c. systems in the use of variable-speed, commutator-type traction motors, with, however, much higher line voltages of 10,000, 15,000 or even 20,000. The use of motors of this type is not, however, an essential feature of the system. On certain electrified lines, referred to below, the traction motors are of the d.c. or the three-phase induction type to which power is supplied from the single-phase overhead line through some form of convertng plant carried in the locomotive or motor coach. The extent of electrification in which locomotives of the convertor type are employed is comparatively small, the single-track mileage of line in these installations being less than 5 per cent of the total mileage of lines electrified on the sihgle-phase a.c. system.

The first practical variable-speed commutator-type, single-phase motor was designed and built in the United States in 1902, although experiments had been proceeding since 1891. Until recently motors of this type could only be designed for practical railway operation where alternating current of a lower frequency than that of the public supply was used. Thus, on lines electrified on this system in Europe the frequency is 15 or 16⅔ cycles; in the United States 25 cycles. The traction current is therefore provided either by special low-frequency, single-phase, generating stations, or by substations equipped with frequency-changing motor generators taking power from the public supply at the standard frequency.

The principal attraction of the single-phase a.c. system is the possibility of reducing the cost of the overhead line equipment, which on account of the small current to be transmitted requires only a small cross section of copper conductor. Thus, for the same horse-power the current on a 15,000V, single-phase system is not much more than one-tenth of the current on a 1500V d.c. system. The complete equipment, including the supporting structures and their foundations is therefore lighter and less costly.

Spacing of Substations.—In comparison with d.c. systems, there is the possibility of a material reduction in the number of substations or points at which power is fed to the conductor rails or overhead lines, due to the use of a high voltage and the resulting small current to be transmitted to the trains. In practice, however, the arrangement and relative cost of the distribution system including substations or feeding points are determined by several factors. These are the source of power supply, whether from the public supply system or from special low-frequency power stations; the provision of low-frequency, high-voltage distribution lines paralleling the track; interference with parallel communication circuits; permissible line-voltage drop; protection against the effects of electrical faults; the electrical sectioning of the contact lines, and the locations of branch line junctions.

The substations themselves, in which power from the public supply system at the standard frequency is converted to single-phase power at a lower frequency, are necessarily expensive as they contain rotating machinery, and are comparatively inefficient. For example, the substations in Sweden have a service efficiency of about 84 per cent. This compares with an efficiency of 95 to 96 per cent achieved by modern rectifiers in substations for the d.c. systems.

The A.C. Traction Motor and Control Gear.—Single-phase commutator motors must be specially designed to overcome or mitigate the tendency to destructive sparking at the brushes due to the inductive effect of the alternating magnetic field. This tendency can be suppressed when the speed of the motor has reached a certain minimum, but when starting, usually at full torque, the sparking can be kept within practicable limits only by special arrangements of the windings and brush gear, and preferably by the use of low-frequency current, as the tendency to sparking is proportional to the frequency. In general, the commutation performance of modern low-frequency, single-phase motors, as now developed, approaches that of d.c. traction motors. Their first cost is, however, greater, and, owing to the more complicated windings and the additional brush gear, the maintenance costs are rather higher.

The control gear for single-phase a.c. motors is not so simple as that used with direct current. An important part of the tractor equipment is the heavy and bulky step-down transformer, which may be either oil-cooled or cooled by air blast. It is usually carried in the body of a locomotive, but with a multiple-unit motor coach it may be mounted in the coach body, which involves giving up seating capacity, or, if the coach is long enough, under the body between the bogies with special strengthening of the underframe.

Interference with Telecommunications.—In the simplest combination of overhead line equipment and substations there are no high-voltage, low-frequency distribution lines paralleling the track. If sufficient precautions are taken to prevent interference from the railway power lines in neighbouring communication circuits the substations may be widely spaced. For example, on the Stockholm–Gothenburg line there are only five substations at an average spacing of 58½ miles. For the entire network of 2320 route miles of Swedish Railways electrified between 1923 and 1942, there are only twenty-six substations. On the Swiss and German electrified lines, the substation spacing is on the average about 25 to 30 miles. In these countries special steps are taken to prevent interference disturbances in the communication circuits. In Switzerland and Germany, all or most of these circuits have been put into underground cables. In Sweden an additional insulated wire is provided for each track, electrically connected to the track rails about every 2 miles, together with a booster transformer in circuit with this wire located about midway between the connection points, and certain alterations involving considerable extra expense have been made to both the railway and the State communication lines.

In the extensive electrified system of the Pennsylvania Railroad, each of the two or four tracks is equipped with a two-wire, single-phase, 132kV, 25-cycle distribution line in addition to the contact line, the latter being fed from the distribution line by step-down transformers spaced on the average 8 miles apart. The communication circuits are mainly in underground or overhead cables, and are to a certain extent shielded by their metallic coverings. Arrangements to limit the inductive effect of the load currents include the provision of an additional shielding wire along the line bonded to the rail return system.

Examples of Single-Phase Electrification.—Although there is a large mileage of main line electrification in Europe and America on the single-phase, high-voltage, low-frequency system, the principal example of suburban electrification of any magnitude on this system is in the Philadelphia area, which is connected with the electrified main lines of the Pennsylvania Railroad. In this area, the Pennsylvania Railroad operates a stock of multiple-unit trains, comprising 431 motor and trailer coaches in all, the majority being motor coaches each equipped with two motors, although fifty steel coaches are about to be equipped with four motors each. The Reading Company run their suburban services in the same district with 100 coaches, all of them motor coaches. On both railways the line voltage is 11,000 to 12,000 at 25 cycles. It may be recalled that the suburban services on some 40 route miles of the former London, Brighton and South Coast Railway were operated with multiple-unit trains on the single-phase, 25-cycle a.c. system at 6600V, using an overhead line; this was superseded in 1929 by the present d.c. conductor rail system to secure uniformity throughout the Southern Railway.

As already mentioned, electrification on the single-phase a.c. system has not been exclusively dependent on the use of variable-speed commutator-type motors. In the United States, the Norfolk and Western Railway in 1915, and the Virginian Railway in 1925, electrified certain heavily graded sections on this system with an overhead line at 11,000V, 25 cycles, and with locomotives of the so-called "split-phase" type. In these locomotives the electrical equipment consisted of three-phase induction motors, geared for two alternative constant speeds, viz., 14 and 28 m.p.h., and phase convertors taking power from the single-phase overhead line and delivering three-phase power to the motors. The locomotives were capable of very high tractive effort, being designed to deal with trains of 4000 and 6000 tons on rising gradients of 1 in 50.

The Virginian Railway has recently put into service on the same section locomotives of a slightly different design, in which d.c. motors provide the tractive power and are supplied from the 11,000V overhead line through motor generators. The latter consist of a single-phase synchronous motor coupled to a d.c. generator. The locomotives are noteworthy for their high capacity. They are of the type 2×(Bo—Bo +Bo—Bo) with two articulated bodies. The aggregate horsepower of the sixteen motors is 6800. They are not limited to a speed of 28 m.p.h., but can be run up to 50 m.p.h. or more. They are designed for regenerative braking; about 25 per cent of the power taken for haulage is returned to the line.

These electrification schemes have been designed to meet special traffic conditions, namely, the working of mineral trains of 4000 and 6000 tons on steep gradients. For conditions of working in Great Britain, a design embodying the use of convertors or motor generators offers no special advantage compared with equipment comprising low-frequency, single-phase, commutator-type motors, as extensively used on the Continent and in the United States.

The electrification of the Budapest–Hegyeshalom section (118 route miles, 398 single-track miles) of the Hungarian State Railways, begun in 1931 and completed in 1934, is of special interest in that it was the first railway installation to be carried out on the single-phase a.c. system at 50 cycles. The overhead line at 16,000V is fed from substations containing single-phase transformers taking power from the three-phase 110,000V national network. The locomotives are of the "Kando" type, the equipment consisting of one or more three-phase slip-ring motors supplied from a convertor set of a special design. This set consists of a phase convertor and a frequency changer on the same shaft. The line current is transformed to three-phase by the phase convertor and the frequency changer.

In the original design, each locomotive was equipped with a single 2500 h.p. motor driving through side rods. New locomotives now under construction, in which the single motor is replaced by five smaller motors mounted on one four-wheeled and one six-wheeled bogie, are geared direct to the driving axles. By changing the number of poles and the connections of the frequency convertor, provision is made for five different train speeds, viz., 25, 50, 75, 100 and 125 kilometres per hour. For starting the locomotive the current in the rotor circuit of each traction motor is regulated by a liquid rheostat, the operation of the rheostat being automatically controlled.

The construction of the special convertor set is rather complicated, and liquid rheostats, although simple and efficient, are not regarded with favour in many quarters. For these reasons, the "Kando" system cannot be recommended for the future electrification of the British railways, bearing in mind specially the probability that much of the passenger traffic will be worked by multiple-unit trains.

Metallurgical Topics

Machining of Heated Metals

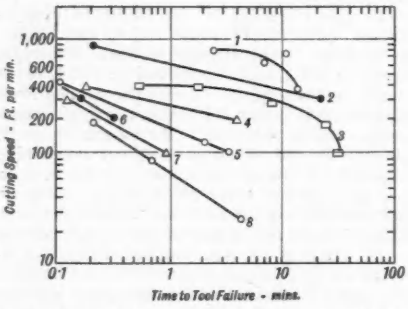
In 1944, Dr. H. W. Gillett, of the Battelle Memorial Institute, suggested that the machining of materials might be facilitated by heating the workpiece. Preliminary tests showed favourable results, and further investigation was sponsored by the Warner and Swasey Company. The results of this work have recently been published by E. T. Armstrong, A. S. Cosler and E. F. Katz.[1]

The hot machining of metals is not new. It was also about six years ago that it was independently suggested by the present director of the British Welding Research Association, Dr. H. G. Taylor, and experiments were carried out with promising results.[2] It was used by Krupps, with carbide cutting tools, during the war,[3] and several American publications have referred to experimental work on the method.[4] A contract was entered into between the U.S. Navy Department and Sam Tour and Co., Inc., that led to work which demonstrated that when ordinary medium-carbon steel was heated to 800 deg. Cent. the rate of removal of metal could be trebled, and that of 55-ton alloy steel doubled. For the high-temperature cobalt-chromium alloys, which are almost unmachinable at room temperature, the increase effected by heating to 800 deg. Cent. was of the order of 125 to 1. Sam Tour and Co. used either gas or induction heating. A. O. Schmidt, in experiments on hot milling, used an oxy-acetylene torch moving ahead of the milling cutter which was tipped with Tantung, the machine parts being shielded by asbestos. The steel used contained about 0·4 per cent carbon with nickel 1·8, chromium 0·8, and molybdenum 0·25 per cent. The surface temperature of the metal removed during the cut was about 650 deg. Cent.; the temperature below the metal removed was stated not to exceed 180 deg. Cent. since no temper colour or discolouration was seen on the milled surface, and the power consumption and impact shock on the teeth of the milling cutter were greatly reduced.

At Battelle, flame heating was employed in the preliminary experiments. It was found that, in cutting 20 : 10 chromium-nickel austenitic steel, tool life was increased tenfold by heating the material to 200 deg. Cent., but the more outstanding results were obtained on other, essentially non-machinable, materials. Vitallium, an alloy used for gas turbine blades (for composition, see Table I), is machined with such difficulty that components of this material are usually cast to size and finished, if necessary, by grinding. Machining at room temperature gives chips that are powdery, an uneven surface and short tool life. At 1100 deg. Cent. the material was machined freely, with long curling chips, the cut surface was smooth and even, and tool life satisfactory. The austenite of a 13 per cent manganese steel transforms to hard and brittle martensite in the process of machining at room temperature, but turning and drilling tests showed that austenitic manganese steel could be machined readily at 650 deg. Cent., as could fully hardened high-speed steel.

TABLE I—*Percentage Composition of Materials Referred to in Fig. 1*

	C	Mn	Ni	Cr	Mo	W	V	Nb	Co	Fe
Stainless	0·08	0·29	9·5	20·0	—	—	—	—	—	Bal.
NE 8949	0·48	1·20	0·5	0·5	0·35	—	—	—	—	"
H.S. tool steel ...	0·72	0·25	—	4	—	18	1·25	—	—	"
Vitallium	0·22–0·25	—	—	25 to 34	5·5–6·0	—	—	—	Bal.	—
NR 76	0·40	—	20	20	4	4	—	4	45	6
NR 74	0·45	—	20	20	4	4	—	4	20	Bal.



Depth of cut, 0·080in. Feed 0·011in per revolution.

Material (see Table I)	Curve No.	Power density, kW per sq in
Stainless	1	5
Stainless	2	Nil
NE 8949	3	5
NR 74	4	10
NR 76	6	10
Vitallium	7	10
H.S. tool steel	5	20
H.S. tool steel	8	5

FIG. 1—*Effect of Power Density on the Tool Life/Cutting Speed Relationship (Armstrong, Cosler and Katz)*

The use of flame heating is inefficient. A continuous heating method is required which confines the heat, as much as possible, to the surface layer which is to be machined away. Armstrong and his collaborators discuss two methods which appeared to hold promise of heating at the required rate, viz., induction heating and arc heating. Induction heating has the advantage of cleanliness and convenience to a high degree ; but, in this particular application it has the disadvantages of high cost of equipment and of poor efficiency. It is necessary for the heat to be put into a very small area at a high power density. With induction heating it is difficult to obtain an adequate power density.

The best heating method found was heating by an arc, struck between the work and a carbon electrode, for which either direct or alternating current could be used. The worst trouble proved to be non-uniformity of heating, caused by the motion of the work, bringing cold metal under the electrode continuously and thus tending to extinguish the arc. Two improvements were made to achieve satisfactory uniformity of heating : (i) the use of a high-frequency high-voltage spark, superimposed on the arc in a manner common to many welding machines, and (ii) magnetic stabilisation of the arc position. Uniformity of heating was checked by hardness tests on hardened and ground bars of a 1 per cent chromium-molybdenum steel. Some results are illustrated in Fig. 1. Hardness tests made before and after hot machining revealed some tempering effect, which, under proper conditions, could be reduced to a minimum. The Rockwell C hardness numbers of NE 8949 before and after hot machining were 42 and 40, approximately equivalent to 395 and 380 Brinell.

Reference to curves 1 and 2 for stainless steel will show that at a constant heating power density of 5kW per square inch, the maximum improvement occurs at a cutting speed of about 600ft per minute, the ratio of tool life being about 8 : 1. No benefit results from hot turning at 330ft per minute, since the two curves intersect at about that point.

The sum of the power required for the machine tool and for heating was about the same as that required for the machine tool alone in room temperature machining. The total power requirements were about the same in the two cases. The utility of the hot machining process must, therefore, be based on other than power requirements. One such consideration is the amount of work that can be done on a given machine tool. For an austenitic stainless steel the capacity of the machine tool is trebled. For less machinable materials the advantage is greater, and in some cases the decision is heavily weighted in favour of hot machining since the alternative would be more expensive finishing methods, e.g., grinding. This applies particularly to some of the high-temperature steels and alloys for gas turbines, such as those referred to in Table I and Fig. 1. In their paper contributed to the recent symposium on this subject, K. J. B. Wolfe and P. Spear remark that the technique of "hot-spot" machining, whereby intense local heat is induced in the component material ahead of the cutting tool, may prove to be of value for the ferritic alloys.

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[3] "The German Hard-Metal Industry," B.I.O.S., Final Report No. 1385, page 55.

[4] *Iron Age*, April 28, 1949, page 66 (A. O. Schmidt); July 21, 1949, page 78 (Sam Tour and L. S. Fletcher); February 9, 1950, page 71 (L. T. Friedman).

Steels for High-Pressure Hydrogenation Plants

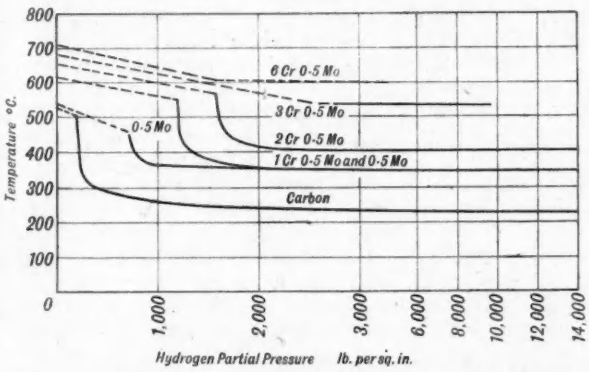
Hydrogenation processes involve the use of hydrogen at high temperatures and pressures, creating circumstances in which ordinary carbon steels cannot be employed. The effect of hydrogen at high pressures and temperatures on steels of different compositions was studied long ago by N. P. Inglis and W. Andrews.[1] Their experience and that of E. B. Wolff and L. F. Otto[2] (communicated in the discussion) enabled three stages of hydrogen attack to be distinguished : (1) absorption of hydrogen causing embrittlement—at this stage the steel can be restored to its original state of ductility by a suitable heat-treatment ; (2) surface decarburisation with the formation of methane—an equilibrium exists between the carbide in the steel, the hydrogen and the methane, and there is a limiting temperature range below which the attack is so slow as to be practically non-existent, though increase in pressure reduces this temperature limit ; (3) fissuring and disintegration. This last stage is due to the continued inward diffusion of hydrogen, resulting in the formation of methane by the reaction of hydrogen and carbide at some depth below the surface of the hot steel. The methane cannot diffuse out as rapidly as it is formed and therefore gives rise to increased pressure, resulting in cracking. The effect is similar to the action of reducing gases on copper (commonly known as the "gassing" of copper), when hydrogen reacts with cuprous oxide present in the metal, and the water vapour formed cannot diffuse out rapidly enough to prevent an increase in internal pressure sufficient to disrupt the material by a network of intergranular cracks.

The work of Inglis and Andrews established the existence of temperature limits, characteristic of the composition and structure of the steel, below which risk of attack was negligible at a pressure of 250 atmospheres (about 3800 lb per square inch). For example, at 250 atmospheres 3 per cent chromium steel was resistant up to 400 deg. Cent. and 6 per cent. chromium steel up to 500 deg. Cent.

The fundamental facts of the phenomenon of hydrogen attack in hydrogenation plant were firmly established by Inglis and Andrews in 1933. Since that time work has been carried out on a large variety of compositions.[3] None of the chromium steels employed by Inglis and Andrews contained other alloy elements, but plain chromium steels suffer severe embrittlement on prolonged heating at 400 deg.–500 deg. Cent. and, therefore, modified compositions,

with 0·5 per cent molybdenum, which show no embrittlement, were employed. Addition of nickel or of silicon brought no improved resistance, but steels containing 3–6 per cent chromium, 0·5 per cent molybdenum, no nickel and very little carbon, sometimes with the addition of vanadium or tungsten, have been widely used commercially for pressure vessels. It was shown by W. Baukloh and H. Guthmann[4] that, contrary to the previous assumption that a minimum of 3 per cent chromium was necessary to prevent attack by hot, high-pressure hydrogen, steels with as little as 0·9 per cent were resistant under certain circumstances.

In pursuance of a policy of economy of materials and conservation of alloys, G. A. Nelson, of the Shell Development Company, San Francisco, returns to the subject in a recent paper.[5] Although high-alloy steels can be used with perfect safety, the more reasonably priced low-alloy steels are often satisfactory. Mr. Nelson summarises the results of tests and operating plant data from which it is possible to establish practical operating limits for carbon and alloy steels for all degrees of severity of service. He sums up the effect of composition by saying the attack is prevented by adding any element forming a stable carbide. In ascending order of effectiveness, they are stated to be: manganese, molybdenum, chromium, tungsten, vanadium, titanium and niobium. All high-chromium austenitic steels are resistant on account of their high chromium content, although, as Inglis and Andrews pointed out, they must be of the types immune from grain boundary carbide precipitation. Carbon steel is perfectly safe so long as its temperature limit for a particular pressure is known, and it is also known that this temperature and pressure condition will not be exceeded. Nickel and silicon have no effect, but phosphorus and sulphur tend to increase attack and should be as low as possible. Mr. Nelson gives curves



Broken line: Decarburisation. Full line: Fissuring. Some of the 3—6 per cent chromium steels also contained vanadium.

FIG. 1—*Operation Limits for Carbon and Alloy Steels in Contact with Hydrogen at High Temperatures and Pressures (Nelson).*

of temperature against partial pressure of hydrogen, based on experience and drawn to indicate the boundary between satisfactory and unsatisfactory performance. The curves are reproduced in Fig. 1. The dotted lines indicate the occurrence of decarburisation not accompanied by fissuring. Under critical conditions, a small change of temperature makes all the difference between successful performance and gradual failure. In the steeply falling parts of the curves behaviour is particularly uncertain and success or failure may be equally common in this range of temperature and pressure.

When other corroding agents are present, additional precautions may have to be taken against their action. For resistance to sulphur as H_2S, which corrodes carbon or low-chromium steels at temperatures above 350 deg. Cent., a 5 per cent chromium, 0·5 per cent molybdenum steel was considered adequate, though a steel with 1 per cent chromium and 0·5 per cent molybdenum did not require replacing for four years. In the presence of ammonia, or nitrogen in the hydrogen, nitriding begins at about 450 deg. Cent. and 2140 lb per square inch, but no pipes or forgings have been known to fail owing to nitriding. To protect against nitriding, if this should be necessary, requires the use of chromium-nickel alloys of high nickel content. Quoting German experience, Nelson states that a hydrogen-carbon monoxide mixture, though itself inert at ordinary pressures up to a high temperature, gives corrosion at high pressures of such severity that special materials must be used, even when the temperature is quite low. A 50 : 50 mixture of carbon monoxide and hydrogen at anything between 250 and 700 atmospheres gave extreme corrosion at 260 deg. Cent., but both above and below that temperature the attack fell off rapidly. With this gas mixture, within the range 150 deg. to 350 deg. Cent., the ordinary constructional steels are badly attacked and special steels must be used. The 13 per cent chromium steel showed great resistance to attack, the surface layer becoming enriched in chromium owing to the formation of iron carbonyl.

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Chromium

IN view of the possible importance of chromium-base alloys for gas turbine blades and similar high-temperature applications, and of the extreme brittleness of these alloys at room temperature—a feature which constitutes one of the biggest obstacles to their use—great interest is at present being taken in the methods of production of pure chromium metal and all possible means of obtaining it in a ductile condition are being investigated.

Dr. W. J. Kroll (who has done so much to develop methods of obtaining the rarer metals like titanium, vanadium and zirconium in a pure and ductile condition) and his associates at the U.S. Bureau of Mines have made an assessment of the more promising methods of producing pure chromium.[1]

Alumino-thermic and silico-thermic processes used for the production of chromium from chromium oxide yield a product that may contain more than 99 per cent chromium, but is very brittle. A metal of that purity (though three times as expensive as low-carbon ferro-chromium) has apparently hitherto met the requirements of the alloy industry, which has only recently been concerned with chromium-base alloys. The investigation at the U.S. Bureau of Mines was undertaken with the idea of studying a number of unconventional methods of making chromium, to determine whether production costs could be lowered and the properties of the product improved. The report contains a detailed discussion of a number of possible processes: preference was given to the reduction of chromium chloride by magnesium, a method analogous to that by which Dr. Kroll had produced ductile zirconium. Chromium carbide may be chlorinated direct to $CrCl_3$, and, assuming that large quantities of $CrCl_3$ could be made available, it would be possible to reduce this salt at lower cost than that resulting from the alumino-thermic method of production. The chromium powder obtained by this process still contained traces of oxide, which could be reduced by dry hydrogen at high temperature. This treatment reduced the hardness of the chromium, but the metal produced was still brittle when cold though ductile when hot. It could be hot-rolled into a thin strip.

The properties of electrodeposited chromium have been studied at the U.S. National Bureau of Standards, but no remedy for the brittleness of this product after remelting has been found, nor was any conclusion reached as to the cause of the brittleness. The reason why chromium is brittle is not known, but in the light of previous investigations by Dr. Kroll on other so-called brittle metals, it may be assumed that the presence of oxides or possibly nitrides may be a contributing cause of lack of ductility. All refining operations which involve the melting of chromium present considerable practical difficulties, as the metal is very volatile at its melting point and it readily attacks many refractories.

The report is not very optimistic about the "iodide method" of van Arkel—in this case the thermal decomposition of chromium tri-iodide on a hot filament held at 1100 deg. Cent. while the vessel is heated to 800–1000 deg. Cent. It is stated that the operation must be carried out in quartz vessels which would be attacked by the iodide at the high operating temperature. The difficulties of putting the iodide method into operation on a large scale are undoubtedly very considerable, but as a source of small specimens of ductile chromium it is regarded in other quarters as promising. It has been under experimental investigation at the Battelle Memorial Institute for some time, and Dr. H. C. Cross, of Battelle, has recently stated that crystals made by this method, though brittle when struck by a hammer, could be reduced 40 per cent in compression before cracking occurred, and that some crystals arc-melted in an inert atmosphere could be similarly deformed. Thus, some increase in ductility is being obtained as the purity of the metal is increased; and as the factors affecting the ductility of pure chromium are better understood, the chance of producing ductile chromium base alloys will be greater.

[1] W. J. Kroll, W. F. Hergart and W. R. Carmody: "Contribution to the Metallurgy of Chromium," U.S. Bureau of Mines, Report of Investigation 4752, December, 1950.

Antimony Plate

IN an article in *Metal Progress* for February, 1951, attention is drawn to the possibilities of antimony as a decorative and protective coating on steel.[1] It is not generally appreciated that pure antimony resists attack by hydrochloric and hydrofluoric acids, and also by cold, dilute sulphuric and nitric acids, that it is relatively resistant to tarnishing in a variety of industrial environments, and that it is easily buffed to give a highly reflective surface. Attempts to produce adherent electrodeposits of antimony have hitherto not been very successful; bright antimony deposits are brittle and flake off. Recently two new processes have been reported—one using antimony trifluoride and the other a citrate bath—for depositing antimony with a dull surface, to which a high lustre can be imparted by a light buffing. Antimony plate flows easily, and a high finish on the surface of the steel base is unnecessary; in fact, an etched or sandblasted surface improves adhesion.

When all that can be, has been said in favour of antimony plating, the disadvantages associated with it are considerable, though some of them are shared by other metals commonly used for plating. Its resistance to wear and to scratching, though somewhat better than that of tin, zinc or cadmium, is not very good; it is much softer than nickel, chromium or speculum metal. Like copper, nickel, tin and lead, it is electropositive to iron; it therefore functions solely by virtue of its own resistance to corrosion, and the coating to be effective must possess a high degree of freedom from porosity. On account of its toxic properties it cannot be used in food containers. Moreover, its continued availability is by no means certain.

[1] A. Bregman: *Metal Progress*, February 1951, page 245.

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RAILWAY ELECTRIFICATION

LAST week we published a summary of the report of a committee appointed in April, 1948, to review the methods of electric operation used on railways in this country and the system or systems to be adopted in future electrification. Briefly, its terms of reference required the committee to determine whether recent progress in electrical practice had affected the conclusions of the Pringle Committee's report in 1927—the main recommendation of which was that electrification should be by direct current at 1500V or 750V, with the proviso that a voltage of 3000 might be approved in special circumstances. More particularly the 1948 committee had to examine whether a single system should be adopted in all future electrification schemes that may be contemplated, due regard being given to the question of connecting services in the event of two systems being approved.

Although no outstanding advances in the principles of railway electrification have been established in the past twenty years, there has been substantial progress in details of design and construction. More recently, however, there have been some promising technical developments. For instance, the single-phase a.c. system, which is characterised by high voltages, low currents, and reduced cost of overhead line equipment, has received a fresh lease of life through the decision of the French National Railways to carry out comprehensive trials with power at 50 c/s on the contact wire. As indicated in our issue of February 2nd last, the French authorities appear to be well satisfied with the preliminary results obtained from the first of three locomotives running between Aix-les-Bains and La Roche-sur-Foron. While two of the locomotives are to be fitted with a.c. commutator motors of new design, the third will be driven by d.c. motors fed from a motor generator set. For the present, however, while the 50 c/s system is still unproven, the committee is clearly unable to recommend its adoption as the standard for future electrification in Britain. Nevertheless, its potential merits for the conversion of secondary lines justifies the committee's suggestion that, when economic circumstances permit, the Railway Executive should consider an experimental single-phase installation. In the meantime, there is little to be said for the other possible alternative to d.c. traction—the three-phase system, in which no recent technical advances have been made to outweigh the inherent disadvantage of its complicated overhead track equipment. To clarify the choice between the better-known d.c. and single-phase systems, the committee made comparative estimates of four alternatives —750V, 1500V and 3000V d.c., and 20kV, single phase, 16⅔ c/s—as applied to each of four typical schemes. Two of these schemes represent important main lines, with high traffic densities but with different ratios of passenger and freight, the third typifies a main line of secondary importance, while the fourth is primarily an outer suburban line. The results of the committee's analysis show that the annual expenses, including capital charges, for each of the four schemes, would be considerably higher for 750V d.c., or for single-phase a.c. than for the 1500V or 3000V d.c. systems. There is not much to choose between the two higher voltage d.c. systems and the only material advantage of 3000V appears in the third scheme, which is the lightly loaded line. However, account must be taken of existing electrifications, including the Southern Region, making allowance for dual running over different systems. When this requirement is considered the balance turns in favour of 1500V, since there is no difficulty in designing multiple unit trains for dual operation on 750V third rail and on the 1500V overhead line, whereas similar equipment for 750V and 3000V would be more costly. The report therefore recommends that 1500V d.c. should be the standard for future electrification (excepting extensions to existing systems) and suggests that 3000V d.c. might be considered in the case of more lightly loaded lines.

The 1948 committee, it will be seen, was mainly concerned with specific questions about the system of future electrification. But it would be idle to regard its report as merely an academic study of what might be. It must necessarily be considered as a guide and a reminder of what can and very likely will be. We are reminded, indeed, that present conditions do not seem any less favourable to electrification than they were at the time of the Weir Report (1931); and that in certain respects they may be considered more favourable. For there are good reasons—such, for instance, as the increased cost of coal and the need to economise in its use—to believe that changed conditions may have accentuated the advantages of electrification. Even if such factors as improved amenities are ignored, main line electrification is economically justified if the additional fixed charges incurred are more than balanced by the consequent reduction in working costs. This saving depends mainly on traffic density and it is estimated in the report that the minimum density for electrification on British Railways lies between three and four million trailing ton miles per annum, per mile of single-track running line. On this limited basis, electrification turns out to be justifiable, according to the Committee, on 14,700 single-track miles, representing 43·4 per cent of the total of British Railways and embracing the majority of the main lines. There are, moreover, certain significant trends that should be considered. First there is the public demand for more frequent and faster main line passenger services, which may be expected to result in an increase in the number of long-distance day expresses and a decrease in their size. A growth in traffic would be a logical corollary to any such change. Secondly, as the report points out, on the subject of goods services, to satisfy the pressure from industry for rapid deliveries would require a substantial reduction in the size and weight of goods trains, with a corresponding increase in their number. Changes such as these tend to emphasise the advantages of electrification. But, of course, there are arguments upon the other side, which favour the retention, if not necessarily of the steam locomotive, at least of individual self-contained power units for railway operation. Moreover, on economic grounds, the demise of the "steamer" has again and again been prophesied in this century; yet, like Charles II, it has been "an unconscionable time dying." We do not believe it will be "dead" in this country for very many years to come, even though, in agreement with the Committee, we feel we must "look forward to a considerable conversion from coal to electricity in the next quarter of a century."

FLYING SAUCERS

THE mystery of "flying saucers" in America has been solved. With the recent official announcement by the nuclear physics branch of the U.S. Office of Naval Research explaining that the "flying saucers" are, in fact, unmanned plastic sounding balloons having the unusually large diameter of 100ft, there should come to a close one of the most speculative and sensational phases of recent American newspaper history. It has now been disclosed that since 1947 these so-called "skyhooks" have been sent up in various parts of the United States to elevations of

as much as 20 miles, for the purpose of gathering information on cosmic rays.

The "flying saucer" delusion started as long ago as June, 1947, when a Mr. Kenneth Arnold, of Boise, Idaho, on piloting his own aeroplane near Mount Rainier, Washington, saw "a terrific blue flash" and "nine peculiar objects about 23 miles away travelling at a rate of 1200 m.p.h."! In view of the fact that the U.S. Navy frequently sends up clusters of balloons, there is nothing strange about seeing a string of nine "saucers"; however, Arnold could not possibly have observed much if the objects were indeed travelling at the speed of 1200 m.p.h. In an endeavour to sift truth from fiction, the U.S. Air Force—presumably ignorant of what the U.S. Navy was doing—duly inaugurated "Project Saucer," a task which called for the critical examination of hundreds of eye-witness accounts. It is the considered opinion of the American authorities that nearly all such reports came from honestly mistaken persons. Sunlight reflected by an aircraft, wind-blown objects, the light on a weather balloon, a meteor and the planet Uranus in certain positions accounted for what honest observers thought were "saucers." It is a well-known psychological fact that errors are made frequently in identifying objects, and that few eye-witnesses of events can be expected to describe accurately and without adornment what they observe. The apparent lack of evidence to support these eyewitness accounts led to the discontinuation of "Project Saucer" on December 27, 1949. Nevertheless, this did not put an end to the wild imaginings and the false deductions, which are the basis of such incredible stories as the following one, which, last year, made front-page news in the popular Press of the United States. A salesman in Los Angeles had a tale to tell of a "flying saucer" which had crashed into a Mexican mountain. In the "saucer" were found the corpses of two midgets, 3ft tall and covered with hair! Perhaps this story provided inspiration for Frank Scully's "Behind the Flying Saucers," a book recently published and widely read which also deals with midgets from another world who are found in a space ship. There can be no doubt that in power of imagination, Scully eclipsed all competitive interpreters of "flying saucers!"

Now that the Office of Naval Research has announced officially that the "flying saucers" are, in fact, large plastic balloons, weighted with measuring instruments and a wireless transmitter to signal the information gathered by the instruments, we can only wonder why so much time and effort were lavished on "Project Saucer." Why all the secrecy? Gas-filled balloons are not new to physicists studying cosmic rays in the stratosphere. To enlarge such a balloon to a diameter of 100ft is hardly a feat which must be regarded as a military secret. Had a frank statement been made in 1947 that experiments were being conducted with large sounding balloons there would have been fewer fantasies about "flying saucers." And now, has the last been heard of these strange craft? Probably not. The denials issued by the U.S. Air Force two years ago had no effect. On the contrary, more stories of "flying saucers" were circulated after "Project Saucer" was discontinued than before. There is reason to believe that even larger, improved sounding balloons will soon float into the upper atmosphere. When they do Americans will probably hear more fantastic accounts of mysterious sights unless the American Forces realise, at last, that unnecessary secrecy does not pay. Can we feel sure that similar unnecessary and undesirable secrecy about technical matters is not being imposed in this country?

Obituary

CYRIL BATHO

We regret to have to record the death of Dr. Cyril Batho, M.I.C.E., which occurred at 7, George Road, Birmingham, on Friday, March 23rd. Until his retirement in 1949 he had been Professor of Civil Engineering in the University of Birmingham for twenty-five years.

Cyril Batho was born in Liverpool on June 21, 1885, and was educated at Liverpool College and Liverpool University. In 1908 he went out to Canada to become a lecturer in civil engineering at McGill University, but returned to Europe two years later to take up post-graduate studies at Charlottenburg. In 1911 Batho again went to Canada as assistant professor at McGill University, and in the following year he was appointed assistant designing engineer on the New Quebec bridge. During the first World War Dr. Batho served as research officer to the Canadian Machine Gun Corps, and immediately after the war he spent some months as a technical assistant at the Royal Aircraft Establishment at Farnborough. He then lectured for a time at Trinity College, Cambridge, before returning to Canada at the end of 1919 to become Associate Professor of Applied Mechanics and Hydraulics at McGill University. He remained there until his appointment to the Chair of Civil Engineering at Birmingham University in 1924, from which he retired in 1949 with the title Professor Emeritus.

Dr. Batho was a member of the Institution of Civil Engineers and the Institution of Structural Engineers, and from 1929 to 1936 he served on the Steel Structures Research Committee.

Literature

Great Engines and Their Inventors: The Story of Machine Power. By G. S. Ranshaw. London: Burke Publishing Company, Ltd., 180, Fleet Street, E.C.4. 10s. 6d.

This is a popular book which would perhaps be better entitled "Little and Big Engines," for the earliest and some succeeding engines were anything but "great" ones, as will be realised if we instance that the total horse-power of all the engines built by Boulton and Watt during their twenty-five years' partnership did not equal the output of a medium-sized turbo-generator or of a water turbine of to-day. The volume merits notice because it is so largely free from froth such as the oft-repeated statement that Watt was the inventor of the steam engine by watching his mother's kettle blowing off steam over the fire. The early part of the work brings out the discovery that the atmosphere has weight, exemplified in the experiments of Otto von Guericke and in the atmospheric engine of Thomas Newcomen. Both are styled "engineers," although the former was the burgomaster of Magdeburg and the latter an ironmonger. Watt and Trevithick are faithfully dealt with. Stephenson is not claimed as the inventor of the locomotive; his "Rocket" (1829), however, is stated to be preserved at Euston instead of at South Kensington. Parsons's steam turbine and his "Turbinia" are adequately treated. The I.C. engine period is well represented by the gas engine, the petrol or gasoline, the aero and the heavy oil engines. Regretfully, the term "diesel" is used for all forms of compression-ignition engines, and it looks as if we shall never get his name confined to Dr. Diesel's original conception. The jet engine and its variants are dealt with, and finally, a few words are said about atomic energy to show that, at present, it has to be turned into heat before we can make use of it. The diagrams in the book are crude and not as good as should be exemplified in a book which appears to be largely intended for the youth who meditates an engineering career or an apprentice just launched upon it.

Works Management and Organisation. By P. S. Houghton, A.M.I.Mech.E. London: E. and F. N. Spon, Ltd., 15, Bedford Street, W.C.2. Price 25s.

King Solomon said that "of making many books there is no end," and certainly this is true of those on management and organisation; but fortunately, in each one the matter is approached in a different way, the one before us being no exception. The book is well set out and gives a brief outline of the many phases of management, with useful suggestions as to the approach to the various problems that arise, while stressing the importance of developing a clean-cut organisation free from overlapping and duplication.

After defining management and its scope in the first chapter, and giving proposed layouts for different-sized works, the author in the succeeding eighteen chapters proceeds to a consideration of the various departments involved, which comprise respectively: sales; drawing-office, with its problems as to standardisation; personnel; time recording, with the many mechanical aids now available; production planning; production control; costing, with a short description of the various methods of recovering factory expense (or oncosts); estimating; purchasing, including sub-contracting; storekeeping and the control of materials; process planning; motion study, its aim and the methods of undertaking; time studies, and how to take them; rate fixing, with the different schemes for payment by results, and the pros and cons of the various attempts to evolve one that will be fair to employer and employee alike; tool and plant recording; inspection, including a note on quality control; power supply, heating, lighting, &c.; and finally, the question of maintenance. Such is a brief outline of the work.

In so wide a field it would be surprising if there were not points which we should wish to criticise, or at least to join issue with the author, and we feel he would have been well advised to indicate the different kinds of management, beginning with the military and ending with the functional, for while he speaks of "departments being placed on a functional basis," he does not explain how functional management can be run without the unlucky operator having more than one master. The reader is rightly told that in reorganising an old-established firm on modern lines considerable opposition is likely to be encountered, and that this necessitates giving wide powers to the one primarily responsible for the change, but it might also be suggested that much can be done by assembling together all who would be called upon to

work to the new order, even down to the most junior clerk, and in an informal talk explaining frankly to them the requirements and the need for intelligent co-operation. We notice that in the chart for a medium-sized factory the author advocates putting inspection under the managing director or general manager, whereas in the large factory it appears under the works manager, and we wonder why he makes this important distinction. It is considered good practice not to have the chief inspector reporting to the official directly responsible for the actual production of the goods. Similarly, it is doubtful whether it is the best policy to have ancillary services, such as costing, estimating, rate fixing, &c., under the works manager. By having the cost accountant reporting to the chief accountant there is more likelihood of the cost account being satisfactorily interlocked with the financial account. Again we notice that Mr. Houghton would like the cost office to check the price before an order is accepted, whereas it would appear to be desirable for the cost accountant to concentrate exclusively on facts, while the intelligent estimator will have to take into account a number of contingencies, and make allowance for the effect that a potential order would have on the incidence of factory expense. Further, the head of the estimating department will lose interest if he feels that a fine-tooth comb is to be drawn through his own work. We should like to see a form proposed for the comparison of estimated cost with the actual, from which occasional "inquests" can be held into any serious discrepancies between the two. In preparing estimates it is suggested that the form used should have three distinct sections: material, labour and factory expense, the first based on the specification from the drawing-office, the second on information from the rate fixer, and the factory expense on the cost records, while all the contingencies and incidentals will be applied as the result of the personal experience of the estimator. We agree that the most reliable method of recovering oncost is by the machine-hour rate method, but feel it would be wise to indicate the care that should be taken when using it for estimating purposes during periods of slackness. In dealing with store-keeping the author, in common with many others, only arranges for a maximum and minimum to be shown on the store card, whereas by adding an "ordering level" the storekeeper will not wait until the minimum is reached nor will he order unduly early. The foregoing remarks are not intended in any way to detract from a useful book, which will give the student a considered and logical approach to an important subject, and will also afford food for thought for the conscientious manager, but suggestions are made with a view to future editions.

The author draws attention to many considerations which have not been sufficiently stressed by previous writers, among which we are glad to notice that he emphasises the necessity for periodic inspection and overhaul of machine tools and plant, a matter that too often receives but scant attention.

The book closes with a bibliography, from which, however, a number of valuable works have been omitted. It is a great advantage to the student to have guidance as to where to turn to pursue in detail those branches that have necessarily been treated briefly in "Works Management and Organisation."

INSTITUTION OF NAVAL ARCHITECTS.—It was recently announced by the Institution of Naval Architects that the Assistant Secretary, Mr. P. J. Shilham, will be retiring at the end of this year.

SHORT NOTICES

Traction Engines Worth Modelling. By W. J. Hughes. London: Percival Marshall and Co., Ltd., 23, Great Queen Street, W.C.2. Price 12s. 6d.—Traction engines have for many years been one of the favourite subjects of model makers, and their continued popularity is still evident from the number of very fine examples of engines which are to be seen each year at the Model Engineer Exhibition. This book describes in full detail the design and construction of a prototype traction engine which will be of interest and value to all who contemplate the making of a model engine. It also examines the mechanical and other details of a number of well-known makes of engine, which, in the not too distant past, achieved a distinction which will be long remembered by steam traction enthusiasts. Throughout the book the author's affection for the steam traction engine is obvious, and he has included many personal experiences which are not only entertaining, but add considerably to the interest of the descriptive matter. A number of excellent photographs of well-known engines are reproduced as well as detailed drawings particularly intended for model makers. All model makers will enjoy reading this instructive book, and it also provides entertaining reading for the many engineers of the older generation who look back with affection to the days of steam traction on the roads.

Microwave Measurements. By H. M. Barlow and A. L. Cullen. London: Constable and Co., Ltd., 1950, 12, Orange Street, W.C.2. Price 30s.—Following the spate of books from the United States, dealing with various aspects of microwave technique, it is gratifying that this addition to the limited number of publications on the subject in this country should be of such good standard, both in content and in mode of presentation. The authors have very wisely concentrated on the general principles of microwave measurements rather than on attempting to give detailed descriptions of particular forms of measuring equipment, and in providing for ready access to the latter through ample lists of references at the end of each chapter.

The book is composed of twelve chapters, the first two of which afford an introduction to the characteristics of guided waves and to the concept of wave impedance, supported by a comprehensive treatment of the means available for impedance transformation. The remaining chapters deal in turn with the properties of cavity resonators, the measurement of wavelength and frequency, standing wave measurements, matching and transmission systems, power measurement, attenuation and Q-factor, electrical properties of materials, receiver measurements, transmitter measurements, and measurements on aerials.

Much of the information contained has not previously been collected together in book form and its ready accessibility will be of considerable value to communication engineers and to scientists who are interested in the use of microwave methods for the study of physical and chemical phenomena. The book concludes with a number of mathematical appendices.

BOOKS RECEIVED

Gas Turbines for Industrial Problems. By R. J. Welsh. Surrey: The Technical Press, Ltd. Gloucester Road, Kingston Hill. Price 7s. 6d.

British Catalogue of Plastics. Edited by E. Molloy. London: The National Trade Press, Ltd., Drury House, Russell Street, W.C.2. Price 50s.

A Course of Reinforced Concrete Design. Second edition. By T. J. Bray. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 30s.

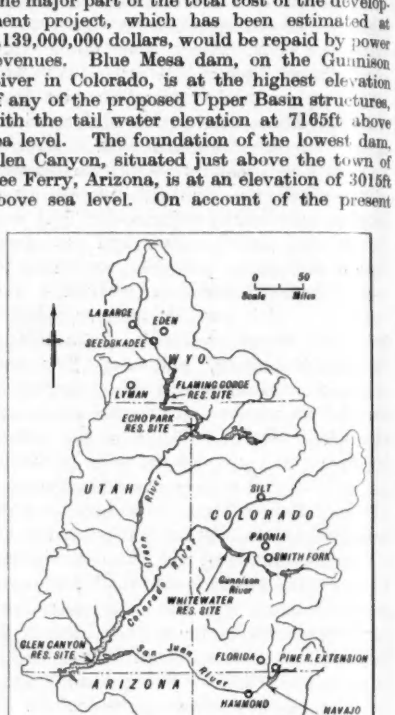
The Highway Engineers' Pocket Book. By F. G. Royal-Dawson. London: E. and F. N. Spon, Ltd., 15, Bedford Street, W.C.2. Price 12s. 6d

Britannica Book of the Year, 1950. Edited by John Armitage. London,: Encyclopædia Britannica, Ltd., 102, Dean Street, Soho Square, W.1. Price 50s.

Ripper's Heat Engines. Third edition. By A. T. J. Kersey. London: Longmans, Green and Co., Ltd., 6 and 7, Clifford Street, W.1. Price 7s. 6d.

Development of the Upper Colorado River Basin

A PLANNING report by the U.S. Bureau of Reclamation dealing with the development of water and power resources of the Upper Colorado River Basin has been approved by the Secretary of the Interior and has now been submitted to the five Rocky Mountain States, portions of which are drained by the river. The report outlines the eventual construction by the Bureau of Reclamation of ten dams and reservoirs with a storage capacity of 48,500,000 acre-feet of water and with a hydro-electric generating capacity of 1622MW. Furthermore, there would be numerous participating irrigation projects, and more than 2,000,000 acres of land would benefit eventually. The major part of the total cost of the development project, which has been estimated at 1,139,000,000 dollars, would be repaid by power revenues. Blue Mesa dam, on the Gunnison River in Colorado, is at the highest elevation of any of the proposed Upper Basin structures, with the tail water elevation at 7165ft above sea level. The foundation of the lowest dam, Glen Canyon, situated just above the town of Lee Ferry, Arizona, is at an elevation of 3015ft above sea level. On account of the present



UPPER COLORADO RIVER DEVELOPMENT

national emergency, the report recommends that only five of the storage dams and eleven of the associated irrigation projects should be proposed for initial authorisation. The five storage projects are Echo Park and Flaming Gorge, on the Green River; Glen Canyon, on the Colorado River; Navajo, on the San Juan River, and Whitewater, on the Gunnison River. These five dams and reservoirs, which are indicated on the accompanying map, would provide 38,480,000 acre-feet of storage capacity and 1150MW of hydro-electric generating capacity. The initial participating irrigation projects would be the first phases of the Central Utah project, in Emery County, Utah; the Florida, Silt and Smith Fork projects, in Colorado; the Pine River Extension project, in Colorado, and New Mexico; the Hammond project, in New Mexico, and the La Barge, Lyman and Seedskadee projects in Wyoming. In addition, the report proposes that the already authorised Eden and Paonia projects, in Wyoming and Colorado respectively, be included in the new development plan.

The following particulars relate to the five storage structures, which have been proposed for initial authorisation. Echo Park dam, on the Green River in Colorado, is to be a curved concrete gravity structure rising to a height of 690ft above bedrock. The reservoir is to have a storage capacity of 6,460,000 acre-feet, including 5,460,000 acre-feet of live storage. When filled to capacity, the reservoir would have a surface area of 43,000

acres. The power plant is to consist of four 50MW units and would have a mean operating head of 475ft. Ashley dam, at the Flaming Gorge reservoir site, is to be a concrete gravity structure having a height of 491ft above bedrock. The Flaming Gorge reservoir would have a total storage capacity of 3,940,000 acre-feet, including an active capacity of 2,950,000 acre-feet. The power plant is to consist of three units with a total installed capacity of 72MW, operating under a mean head of 395ft.

Glen Canyon dam, on the Colorado River, in Northern Arizona, will be a curved concrete gravity structure rising 700ft from bedrock. The reservoir created by the dam would have a storage capacity of 26,000,000 acre-feet, including 20,000,000 acre-feet of live storage. The reservoir, when filled, would have a maximum water surface of 153,000 acres and would extend about 186 river miles up the Colorado River, nearly to the mouth of the Green River, and 71 river miles up the San Juan River. This reservoir would be the principal sediment repository in the Upper Basin. In 200 years, at present rates of sediment flow in the river, silt deposits would fill all inactive storage space and reduce the active storage by half. The power plant of Glen Canyon dam would consist of seven units with a total installed capacity of 800MW, operating under a mean head of 480ft.

Navajo dam, on the San Juan River, in New Mexico, is to be an earth-fill structure 360ft high. Its reservoir would have a total capacity of 1,200,000 acre-feet, including an active capacity of 1,050,000 acre-feet. The power plant is to have three units with a total installed capacity of 30MW, operating under a mean head of 275ft. Finally, Whitewater dam, on the Gunnison River, in Colorado, will be an earth-fill embankment rising 335ft above bedrock. The reservoir would have a capacity of 880,000 acre-feet, including an active capacity of 470,000 acre-feet. The power plant is to comprise three generators with a total installed capacity of 48MW, with a mean power head of 220ft.

The storage project as a whole is economically justified by a "benefit-to-cost ratio" of 1·8 to 1. According to the report, the net revenue from the project will repay all reimbursable costs within fifty years after completion, and will aid in the return of irrigation costs by the establishment of an Upper Colorado River Basin account. Estimates indicate that credits to such an account would exceed charges by more than 600,000,000 dollars in seventy years of operation.

Sediment control was one of the major factors to be considered in the planning of the storage project, and it was determined definitely that silt would not hinder the capacity of the project. A total capacity of 20,000,000 acre-feet would be provided in the various reservoirs to accommodate sediment, which would be deposited in the course of the next 200 years, according to present rates. More than three-quarters of the sediment will enter the river below all potential reservoirs except the Glen Canyon reservoir, and the bulk of the sediment storage space has, therefore, been reserved in that reservoir. Although all planning was based on present rates of sedimentation, it has been pointed out that improved methods of land management are likely to extend the period of protection against sediment encroachment considerably.

CHEMICALS FROM WASTE FUELS.—Work at the Fuel Research Station, Greenwich, may result in finding a use for low-grade fuels. An experimental plant is working on the conversion of coal-washery slurry into water gas, which is a potential source of valuable chemical products. The new process, if successful, could reduce the present cost of water-gas by 50 per cent and release over a million tons of high-grade coke annually for other uses. The process takes place in a cylindrical metal retort and the difficulty of using finely divided fuels has been overcome by adopting the fluid bed technique. In this process steam is blown in from below at a pressure which keeps the fine dust in suspension. Perfection of the process would reduce the cost of producing chemicals from coal and benefit countries which have large deposits of low-grade coal.

The Institute of Metals

No. II—*(Continued from page 376, March 23rd)*

ON Wednesday, March 14th, the first papers to be presented constituted a symposium on "Metallurgical Aspects of the Cold Working of Non-Ferrous Metals and Alloys."

They were "Fundamental Aspects of the Cold Working of Metals," by Dr. Cook and Dr. Richards; "The Deep Drawing and Pressing of Non-Ferrous Metals and Alloys," by Dr. J. D. Jevons; "The Cold Rolling of Non-Ferrous Metals in Sheet and Strip Form," by Mr. C. E. Davies, and "Lubricants for the Cold Working of Non-Ferrous Metals," by Mr. S. F. Chisholm.

Discussion

Mr. W. C. F. Hessenberg (Deputy Director, B.I.S.R.A.) said that in all the papers except one, physics, engineering and even chemistry figured about as prominently as metallurgy, and he thought that must be because in fundamental science it was permissible to break down processes into their constituent parts and investigate them separately, whereas in technology each aspect must be considered in relation to the other. Sooner or later it was necessary to make some crude sort of synthesis of fundamental aspects in order to apply them to an industrial problem. For this purpose the symposium was not complete, and really required an additional paper on the mathematical or macroscopic theories of plasticity and possibly a paper on the theory of friction, which played such an important part in all metal-working processes. In Mr. Davies' paper there was a reference to automatic control of strip gauge, a technique which the B.I.S.R.A. was at present investigating. His own appraisal of the situation was that automatic gauge control was perfectly feasible in principle and that the problem was essentially one of devising suitable servo mechanical equipment to operate it. He believed that the difficulties were not as serious as those that had been successfully overcome in naval gunnery and aerial navigation, to mention two of the well-established applications of servo mechanics. Of the need for automatic gauge control he had no doubt. The traditional procedure of watching the flying micrometer and making occasional adjustments to the rolls by power-operated, but manually controlled, screws was altogether too slow in relation to modern rolling speeds.

Mr. Wistreich (B.I.S.R.A.), in observations on the remarks of Cook and Richards on the textures of drawn wire, said that he was surprised by the statement that wire drawing was primarily a process of tension. Wire drawing, just as much as rolling, was a process involving not only tension, but also compression. In those circumstances, it seemed rather surprising at first sight that the texture of drawn wire should be different from the texture of rolled wire and rolled sheet, and, in fact, it was the same as in wire pulled in a tensile test. It was necessary, when thinking of the interior of the material, to think not of drawing and rolling textures, but of wire and sheet textures. The texture was determined by the geometry of the deformation, but the actual technological process left its distinctive mark on the surface of the wire, and a very important factor in the drawing of wire was the reduction per pass. He felt it was confusing to speak of drawing and rolling textures, for at the centre of the material there were wire textures and sheet textures, and when looking to the effects of the actual technique used the most important place was the surface.

Mr. E. C. Larke (I.C.I., Metals Division), commenting on the paper by Davies, said that it was essential for the efficient development of the metal industry for the metallurgist to be fully acquainted with and appreciative of the work of the engineer who designed and provided the means of fabricating metals and alloys. The main theme of the paper was higher rolling speeds, heavier reductions, greater widths and heavier ingots, i.e., increase of production. With this in mind, Mr. Larke then discussed the effect on output of delays which prevented metal from passing through the rolls, and gave an example of the extent of the rise in output due to increasing the roll speed and the coil length, both individually and together. This example showed that neither doubling the rolling speed nor doubling the coil length was very significant as regards increase of output. To achieve a significant increase it was necessary to double both the speed and the coil length. An equally important point brought out by the example was the need to consider ways of reducing non-productive time, since this factor alone was responsible for the fact that the actual output, in this case, was only about 50 per cent of the maximum possible output. He suggested that it would be a good plan for all concerns engaged in the rolling of metals to inaugurate a system whereby the causes responsible for the idle running of plant were systematically tabulated and analysed. Such systematic observations would be of great value to the mill maker, and with that information available those responsible for the conception of schemes involving the operation of interdependent rolling units would be in a sounder position to provide a balanced production unit.

Mr. W. A. Fowler (British Aluminium Company, Ltd.), who also dealt with the paper by Davies, commented on the author's reference, under the heading of gauge control, to the mill of the future in which the roll gap could be set under a preload which would be in excess of the maximum required for any reduction. While this sounded quite attractive, there were many possible variables with which it would be necessary to contend, e.g., the question of speed, a variation of which during any one pass could markedly affect the gauge; strip tension variation; variation in thickness; variations in the distribution and/or quantity of the lubricant. There was also the important question of thermal camber, any change in which due to overheating was disastrous, not only in its effect on gauge, but also on strip shape. All those concerned with rolling would be most interested in any developments on these lines, but he felt that the successful operation of the idea would not be likely to be the answer to all gauge control problems and that the same care as at present would still have to be exercised in other directions until all the factors involved had been brought under more or less automatic control.

Mr. N. H. Polakowski (University College, Swansea) dealt with the question of reversed deep drawing, as raised in the paper by Jevons. Reverse drawing, he said, was something that had been receiving increasing publicity in recent years, but nevertheless the reasons for the superiority of this process over the orthodox, unidirectional drawing

were not always fully understood. He then proceeded to show results which not only demonstrated clearly the superiority of reversed drawing, but explained why slightly larger blanks were required in this process for the same end product. This was caused by the large uniform extension which involved much less thinning of the walls near the bottom of the cup than was the case in straight drawing. The same results also supported Jevons' opinion regarding the usefulness of the general elongation value for assessing the possible drawing properties of a metal, and added weight to Jevons' own doubts on the value of true stress-strain curves for the same purpose. The whole problem dealt with in the paper could be easily shown to be closely related to the more fundamental problem of fracture of metals under the action of repeated stress, or, in other words, to fatigue.

Mr. A. B. Ashton (Frederick Smith and Co.) dealt with the drawing of copper and copper alloy wires on high-speed, multi-die machines from the point of view of lubrication. In the last analysis the purpose of the wire-drawing technologist was to enable machines to produce the maximum amount of wire at the minimum cost, and one found, on looking into the matter, that lubrication or features associated with it played a large part in the economic picture. In the old days of single-hole drawing, lubrication had been achieved by applying to the wire a pure non-aqueous lubricant, such as tallow or rape oil. The advent of the carbide die, however, and the consequent development of high-speed, multi-die drawing, had introduced another requirement—cooling—and it was that requirement which now dominated the whole picture of lubrication in wire drawing. He suggested that lubricating properties had been sacrificed in the interests of cooling, and that attention should be devoted to the development of materials which were superior as lubricants to the soap solutions now used. The aim should be to find a lubricant which would maintain a condition of full fluid lubrication under the high pressures and speeds encountered in wire drawing. He doubted whether such progress could be made as long as a water base was necessary. He pictured something with a film strength higher than was attainable in an aqueous solution. In order to carry further the principle of improved lubrication, while still complying with the necessary requirement of cooling, it might be necessary to employ two separate fluids, for what was primarily a good lubricant might not be an efficient coolant. This consideration led to the following requirements:—(1) the provision of internally water-cooled capstans or cones; (2) the provision of internally water-cooled dies and die brackets; and (3) the provision of a means of applying a lubricant to the wires entering the dies. The use of a superior lubricant at the wire-die interface would lessen the amount of heat to be dissipated, which could also be lessened by the reduction of capstan slip to zero.

Mr. R. B. Sims, referring to the views expressed in Chisholm's paper on the importance of strip lubricant in the cold working of non-ferrous metals, said that it would be interesting to know what steps the oil manufacturers were taking to ensure that the lubricants they provided possessed the necessary properties. It would also be interesting to have from the manufacturers some data on the composition of the lubricants. The analyses of the synthetic rolling oils which had been put on the market had never been disclosed, which was a great handicap to the serious student of rolling. The paper brought forward a completely new idea of the relationship between the main coefficient of friction in the arc of contact and the viscosity of the rolling oil. One point of interest in this respect was that if there was a very low coefficient of friction the strip came out with a dull, velvety surface, which was not desirable in normal practice. It seemed that the oil manufacturers had been forced to produce poor lubricants in order to get the high polish which came from bad lubrication, since a good lubricant would give a dull finish which would not be acceptable to the industry in general.

Major P. C. Varley (British Aluminium Company, Ltd.), in comments on the paper by Jevons, said that the multi-punch press had the advantage in certain circumstances of using the metal slightly warm when deforming it. In laboratory tests he had noted that better results were obtained after the press had been working for an hour or so than had been obtained the first thing in the morning when it was cold. He emphasised the importance of close control of metal temperature in any interstage annealing process which might have to be carried out. This was particularly important with aluminium, which was liable to grow large crystals if it was annealed after a critical amount of strain. When drawing a cylindrical cup in aluminium, a deeper draw was possible with annealed sheet if one had a punch with a hemispherical end than with half-hard or quarter-hard sheet, but the opposite result was often obtained if one used a flat-bottomed punch. He drew attention to a further anomaly in that the reduction obtained with the various temperatures did not only depend on the form of the punch, but also on the method by which the blank holder pressure was applied. In laboratory tests it had been found that there was a marked difference according to whether the metal was drawn with a spring-loaded blank holder or with a blank holder with a positive clearance, where the distance between the blank holder and the face of the die was fixed by distance pieces. Experiments had shown that the condition of the tools was of importance, and that tools polished as carefully as possible, with the polishing carried out in the direction of the metal flow during the drawing operation, reduced the draw load by a significant amount.

Mr. D. A. Barlow, commenting on Jevons' paper, referred to the deep drawing of aluminium alloys. It was stated in the paper that of the aluminium-magnesium alloys, the low magnesium alloys behaved best under the press; but he suggested that this would depend upon the type of operation and would not always be the same. He then showed results obtained with a hemispherical-ended punch on an experimental deep drawing press, operated by a tensile testing machine, and the results roughly followed the trend of elongation and Erichsen values. Similar tests using a flat-ended punch gave a high value for drawability in each condition of heat-treatment. It would be noted that, contrary to the usual supposition, the fully heat-treated material had excellent deep-drawing properties, in spite of the low elongation and high ratio of proof stress to ultimate stress. As the author said, commercially pure aluminium often drew better in the cold-worked tempers than in the annealed or softest condition. The results he had obtained showed that the softest temper might not always be the best, especially where a deep draw without ironing was required, using a flat-bottomed punch. However, where considerable ironing took place he had found that for a wide variety of aluminium type alloys the softest condition and the softer alloys were preferable, in that the ductility remaining after ironing was greater, enabling flanging and later seaming of the can to be carried out with less danger of fracture.

Mr. R. Eborall (B.N.F.M.R.A.), who also dealt with Jevons' paper, said that his Association had been engaged in a study of the problem of the formation of stretcher-strain markings in non-ferrous metals. Dr. Jevons said that metallurgists had drifted into the belief that the absence of a yield-point kink in the stress-strain curves of the non-ferrous metals implied a freedom from susceptibility to such markings; but the fact was that in some aluminium alloys a definite yield point very similar to that occurring in steel could be noted.

Mr. A. T. Churchman (Department of Metallurgy, Birmingham University) suggested that stretcher strains in some non-ferrous materials might be eliminated by excluding nitrogen from the metal or by some addition to the metal which would fix nitrogen, as titanium fixed carbon and nitrogen in steel.

Mr. Edwin Davis (Technical Officer, I.C.I., Metals Division) commented on Jevons' paper from the point of view of the supplier of non-ferrous metals for press work. He was in sympathy with the author's plea for more co-operation between supplier and user, but pointed out that only too often the user did not know what was required. The author emphasised the difficulty of assessing the suitability of sheet metal for press work from the results of the usual mechanical tests and metallurgical examination, but until the manufacturer of sheet received further information he could do little to improve the situation. This meant that more research into the fundamental aspects of deep drawing operations must be carried out, and although this was the field of those primarily interested in making deep drawn products, it was certain that the manufacturers of non-ferrous alloys would gladly co-operate. It was suggested by the author that 70/30 brass work hardened less rapidly than 63/37 brass; but if the latter were free from beta, as it was when supplied for deep drawing, then the differences in rate of work hardening were negligible. In his reference to 80/20 brass for cold drawing operations, the author suggested that the alloy might be even more suitable if the grain size were small, but sheet in this condition would be much harder than was usually considered acceptable. Season cracking was not confined to finished products, and, in fact, it was not uncommon for an intermediate product to be more susceptible to this kind of failure than the completed article. Intermediate annealing of products with high internal stress should not be unnecessarily delayed if stress corrosion cracking was to be avoided. It should be remembered that imposing stresses, either in assembly or in service, might render brass products susceptible to season cracking even though they were previously stress relieved by annealing.

Dr. H. Ford (Reader in Applied Mechanics, London University) said that in the paper of Cook and Richards he was interested in the reference to the authors' previous work in which they concluded that there were two mechanisms of deformation—slip within the crystals followed by some general shearing mechanism. They had investigated the cold rolling process and showed that this second mechanism set in somewhere about 50 per cent reduction by rolling. In recent experi-

ments, Dr. Ford said, he had investigated high conductivity copper in plain plastic deformation in compression and had found some effect which he thought was probably connected with the mechanism which the authors described; but he had found that the onset of this second mechanism could be delayed quite considerably and, in fact, did not set in until about 80 per cent reduction by plain compression, which was a process very much analogous to rolling. Dr. Chisholm's paper, he thought, was a little over-simplified in one or two respects as a description of the mechanism of deformation in rolling. There was no question of two rival and contradictory theories of rolling. It was a question of the geometry of the pass, the magnitude of the tangential frictional drag between the strip and the roll, and the yield stress of the material as to whether slipping took place over the whole arc of contact or whether there might be a small zone where the roll and the material went together. The author suggested that it was possible to have fluid film lubrication in metal-working processes, and in particular in rolling, but personally he thought it was most unlikely that this would ever be achieved. The author also put forward the view that viscosity was the most important factor in deciding a coefficient of friction in rolling, but tests which had been made showed quite clearly that there was no connection whatever between the coefficient of friction in rolling and viscosity. In general, of course, the effect of lubricants in reducing the magnitude of the friction hill was possibly of secondary importance in considering the suitability of lubricants in rolling, since the reduction in the total power consumption was not great as between one lubricant and another. The lubricants were chosen for entirely different reasons.

Mr. Egginton (British Thermostat Company, Ltd.) thought that the paper by Jevons might give the impression that fine grain brasses in the region of 0·010mm to 0·020mm were usually used for press work, when in point of fact they were used very extensively for the deep-drawn, parallel-sided tube, particularly when such tubes were subsequently formed into flexible bellows for instrument and other purposes. Such fine-grain brasses, which were ultimately drawn to as low as 0·003in or 0·004in wall thickness with a tolerance of less than a quarter of a thousandth of an inch did exhibit physical properties which conformed to what was usually termed the quarter-hard condition, but from the blank they cupped satisfactorily to 40 to 50 per cent cup reductions and drew well on such commercial lay-outs as one would normally consider for 70/30 brasses. They were also amenable to fairly rapid higher temperature interstage annealing without grain difficulties.

Professor H. W. Swift (Professor of Engineering, Sheffield University) observed that Dr. Jevons properly divided sheet metal tests into three classes—common, special and imitative. Among the common tests, he set most store on the ordinary tensile test and in particular on the value of general elongation at incipient necking. There were three qusetions that could be asked: How could the tensile test be interpreted to give really discriminating comparative information on drawability? What evidence of real correlation could be produced? How could it be applied as a reliable acceptance test? Dr. Jevons discounted the value of true stress-strain curves because the part in which they showed the most difference from ordinary curves lay beyond the onset of necking, a condition which should not be reached in good deep drawing practice. But it was a fact, Professor Swift said, that in any reasonably deep single-stage draw the whole of the walls of the cup had, in fact, been strained during the operation far more than the strain which took place at the necking point in an ordinary tensile test, and in most cases to the extent of four times as far. It therefore stood to reason that the tensile test merely carried up to the point of necking with any material was clearly not representative of the stress-strain relationships in the greater part of the deep drawing operations. Among the imitative tests, Dr. Jevons claimed that hydraulic tests had the advantage that with the help of pressure and depth gauges a stress-strain curve could be plotted autographically. What was the stress which could be measured and what was the strain? He challenged Dr. Jevons to obtain an intelligible stress-strain curve from these measurements, even by laborious calculations, let alone autographically. Dr. Jevons' criticisms of the cup-drawing test also were not well informed, for he said that opinions differed as to what should form the basis of measurement and comparison in such tests. Had any other criterion been suggested, except the maximum blank diameter from which a cup could be successfully drawn? Dr. Jevons also complained that with this test, for every sample tested, several blanks had to be machined accurately to different sizes, so that tests of this kind must at present be regarded as being more appropriate to research than to the everyday acceptance testing of sheet under industrial conditions. But all that was required for an acceptance test was a single blank of prescribed diameter.

Mr. C. E. Davies (W. H. A. Robertson and Co., Ltd.) said that the paper by Chisholm was a welcome attempt to rationalise the practice of the selection of lubricants for cold rolling of metals, which had in the past been determined largely by trial and error. Unfortunately, the desired characteristics in the lubricant depended on rolling conditions which differed in regard to rolling speeds, reductions per pass, surface finishes required, &c. In the case of brass, in the intermediate or "getting ready" passes, where maximum reductions per pass were required, a high degree of oiliness and viscosity would not seem to be so desirable, as the gripping power of the rolls would be reduced. In the case of finishing, a more oily lubricant was required for several reasons, as a lower coefficient of friction helped to ensure uniform elongation and to deliver flat strip and, in the case of rolling to light gauges, to obtain the desired thickness in a minimum number of passes. Uniformity of roll temperature and maintained roll shape were essential if gauge variation both in length of coil and strip width was to be avoided. Lubricants for aluminium and its alloys presented other problems, and mineral oil of the kind recommended by the author was successfully used, though it was common practice to dilute this with "white spirit" for finishing. In all cases of cold rolling uniform distribution of roll lubricant and the method of application was almost as important as the exact nature of the lubricant itself. Patchy or irregular distribution was obviously bad.

Mr. W. J. Thomas (British Aluminium Company Ltd.) said that the fundamental problem in cold rolling was the reduction of heat, whether it was from the bearings, friction between the strip and the rolls, or the rolls themselves. He thought this matter needed still further investigation. As an operator he had always found it difficult to get a yardstick which would tell him how efficiently the mill was working. He had often found that a good yardstick was how much of the power provided by the mill was being taken out every hour, but of itself it was not sufficient. A better factor on which to work was the roll efficiency, i.e., what proportion of the time or the distance travelled by the roll face was really used. He thought that if most operators could find that out they would be ashamed of themselves.

Mr. Linwood (Davy-United), who spoke as a mill builder, said that one of the ways of improving production efficiency was certainly the use of heavier passes and high mill speeds to cope with them, but more than that was necessary. The utmost use had to be made of available space, and he thought that one of the ways of increasing production efficiency and cutting down costs was to handle the pieces as few times as possible. The problem must be considered from the point of view both of the large manufacturer and the small man. For the big manufacturer, probably the future trend would be along steel mill lines. The aluminium people had followed the steel mill practice, and he believed that the brass producers would do likewise, in their own way. For the small man he did not think there was anything better than the modern 1951 type of brass mill, which used all the advantages of a small work roll, good bearings, lubrication, and so forth.

Mr. Singer (Birmingham University) said that the importance of friction in all metal-working operations was undoubted, and in no metal-working operation was it more important than in the cold rolling process. How could the coefficient of friction in the rolling process be determined? One of the simplest ways was not to worry about the roll mills at all, but simply to squeeze two pieces of metal together and measure the force necessary to effect the transition of one over the other and then to make a direct application of the results to rolling mill practice. There were very serious objections to this method. The second method was to take one fairly well accepted rolling theory and then, by making some indirect observations on a rolling mill, to put in the various values of the observations in a particular formula and extract from it a value for the coefficient of friction. In that method a great deal depended upon the initial assumptions. He did not think any great success had attended the method. The third method was by direct experiment. Attempts in this direction had been made in the past, but the method was beset by serious experimental difficulties. Nevertheless, he felt that this was the way in which most progress would be made, and he thought that it was in this direction that future efforts should be concentrated. Very little was known about the coefficient of friction, having regard to its importance. It made a very great contribution towards determining the rolling load, the power consumption and, hence, the heat generated; it contributed to wear and towards the maximum draught which could be used; but, even more important, it made a contribution towards the actual mode of deformation during rolling. It also made a contribution towards the surface quality and surface conditions of the strip or sheet that was produced by the rolling mill. In view of all this, it was something on which there should be a great deal more research.

(To be continued)

COMMERCIAL CONDITIONS IN TURKEY.—A survey of economic and commercial conditions in Turkey has been published by H.M. Stationery Office, price 4s. 6d. net. It is the latest volume in the series of Overseas Economic Surveys issued by the Commercial Relations and Exports Department of the Board of Trade.

American Low-Power Nuclear Research Reactors

AS a result of the recent decision by the Governments of the United Kingdom, Canada and the United States to release data relating to "low-power" nuclear reactors, information has become available appertaining to the design, construction and operation of four American research reactors, namely: (1) The world's first nuclear reactor, constructed from uranium and graphite at the University of Chicago in 1942; (2) a modified version of the Chicago reactor, situated at the Palos Park site of the Argonne National Laboratory; (3) a uranium and heavy water reactor situated at the DuPage County site of the Argonne National Laboratory; and (4) a homogeneous enriched uranium, light water reactor at the Los Alamos Scientific Laboratory, Los Alamos, New Mexico, considered to be the prototype of the simplest and most economical atomic power plant of the future.

The Uranium-Graphite Reactor

On December 2, 1942, the first self-sustaining nuclear chain reaction was initiated, constituting the first controlled release of nuclear energy. The pile, a large cube of graphite and uranium, had been constructed by a small group of physicists on the staff of the metallurgical laboratory of the University of Chicago. It was constructed in a squash court of the university and operated at a maximum power level of 200W since higher level operation of such an unshielded reactor was considered to lead to radiation quantities injurious to the operating personnel. The operation of this reactor was terminated on February 28, 1943, and it was dismantled and moved to the Palos Park site of the Argonne National Laboratory, where it was reconstructed and provided with a radiation shield. Only twenty-one days were required for the dismantling, moving and reconstruction of the unit and on March 20, 1943, the reactor began to function at Palos Park.

The rebuilt reactor has the appearance of a large windowless, two-storey square concrete building (Fig. 1). Externally, it is 30ft wide, 32ft long and 21ft high. A small laboratory has been constructed on top of the reactor to facilitate experimental work using radiation generated within the pile. The reactor core (Fig. 2) is a cube-shaped pile of graphite, into which lumps of uranium have been embedded, according to a predetermined lattice pattern. The top of the graphite-uranium pile is covered with 6in of lead and about 4ft of solid wood, the small experimental laboratory being constructed above this shield. Various controls and safety rods enter the sides of the reactor from supporting platforms built around the faces or the sides of the unit. Numerous openings are available in the front face of the reactor, so that graphite stringers may be removed and test materials inserted into its active area.

The concrete walls of the unit were first poured with the front and top open, leaving a vault for the reactor proper to be built up, layer by layer, in a space 22ft long and 20ft wide. The basic construction unit for the graphite-uranium reactor was a graphite block, 4½in by 4½in. The length of the blocks varied but most of them were 16½in long. Cylindrical recesses, spaced at 8½in pitch, were cut into the blocks. Uranium cylinders, 2½in in diameter, and weighing about 6 lb, were inserted into these recesses. Blocks prepared in this manner are known as "live" graphite. Other graphite blocks contain no uranium but are used simply as spacing blocks and are known as "dead" graphite. The graphite blocks were cut to length and the uranium bodies were placed into the recesses to provide live graphite rows spaced apart by rows of dead graphite blocks across the pile to form horizontal layers. Each horizontal uranium-bearing layer was spaced from the layer below by a horizontal dead graphite layer, so that a three-dimensional lattice was formed. All the blocks were closely piled to reduce air spaces. To reflect stray neutrons back into the reactor core, the uranium-bearing material was surrounded on all sides by at least 12in of dead graphite. The reactor became chain-reacting or "critical" at the fiftieth layer. An additional four layers of dead graphite were then added above the fiftieth layer to complete the reflector across the top of the reactor.

Because of the relatively small amount of uranium metal available at the time of the construction of the reactor, a large number of the recesses were filled with uranium oxide. To obtain the best effect from the available

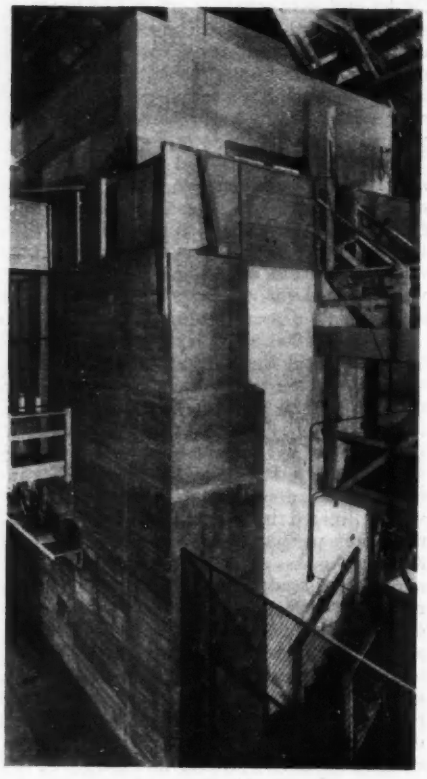


FIG. 1—URANIUM-GRAPHITE REACTOR

metal it was placed in the centre of the reactor and was surrounded with the uranium oxide, lumps. Accordingly, live graphite pieces containing about 10 tons of metal lumps were piled in layers to form a central lattice mass about 13ft wide, 10ft deep and 10ft high, which was positioned between the sixteenth and forty-eighth layers of the reactor. The whole of the reactor contains about 3200 uranium metal lumps weighing about 9 tons. There are about 14,500 uranium oxide lumps, bringing the total amount of uranium in the reactor to approximately 45 tons. The weight of graphite in the reactor is about 425 tons and the total weight of the reactor, including the core, reflector, shield, and lead top, is in excess of 1250 tons.

As the reactor was being built, various openings were provided for the control shim and safety rods. There are five control rods, a regulating rod and a shim rod on the north face of the reactor and three safety rods on the east face. These rods are 17ft long bronze strips covered with cadmium, which has proved to be an excellent absorber of neutrons. The control system is designed for manual regulation of the reactor, for automatic safety control, and for automatic manipulation of the regulating rod in such a way as to maintain constant intensity in the reactor. The safety rods are equipped with 100 lb weights, so that they are pulled into the reactor in the event of electrical power failure.

Extending above the fifty-fourth layer of graphite, there is a dead graphite pier to act as a thermal neutron column for slowing down the neutrons and making them available for research. This column has a cross-sectional area of several square feet, is about 5ft high and passes through the centre of the lead and wood top covering the reactor core. Some neutrons created inside the reactor pass through this column of graphite and, as a result of numerous collisions with carbon atoms, their speed is greatly reduced. The column is covered with a cadmium layer in which a small opening has been provided. Slow neutrons passing through this opening in a narrow beam are used by experimental physicists in certain research activities. The beam of neutrons coming from the thermal column may have a diameter ranging from ¼in to 5ft, depending upon research requirements. Even with a small opening the number of neutrons involved is very large—several millions per second. While the neutrons have been slowed down they still travel at speeds of approximately 4000 m.p.h. On the other hand, fast neutrons travel at 10,000 times this rate.

As the construction of the original reactor proceeded at the University of Chicago, a series of measurements was made to ensure that the critical dimensions were not reached inadvertently. These measurements served also to check the neutron multiplication properties of the structure during assembly so that scientists could predict when the critical point would be reached. A similar procedure was followed in the subsequent rebuilding of the reactor. During the construction of the University of Chicago reactor a 2in by 2in slot running from the north face of the pile to slightly beyond the centre of the pile was built into the eleventh layer. A boron trifluoride proportional counter in a graphite block was moved along this slot to the centre of the eleventh layer. The counting of neutrons was thus achieved and instruments, situated outside the reactor, made a continuous record of the counting rate. To detect the radiation at the periphery of the rebuilt reactor, an ionisation chamber was installed inside the concrete shield near the safety rods.

The success of the initial experiment depended on whether neutrons could be produced faster than they were lost, either by escape to the outside, by non-fission capture by uranium, or by capture by impurities in the construction materials. It was known that the relative chance of fission capture as opposed to competing non-fission processes depended upon the speed at which the neutron travelled and that the opportunities for fission increase if the neutron is travelling slowly. Fast neutrons are slowed down in passing through materials of low atomic weight. Furthermore, the greatest loss of speed per collision occurs if the neutron and the atoms of the moderating material have identical weights. This condition cannot be met in nature but hydrogen, whose atoms weigh approximately the same as the neutron, is a good moderator and deuterium ("heavy" hydrogen), beryllium and carbon are effective moderators. While not one of these elements was excluded altogether from the list of possible moderating materials, it was decided to use graphite in the construction of the University of Chicago reactor. Experiments have shown that high-speed neutrons resulting from the fission process are practically all reduced to low speeds, suitable for fission capture, after passing through about 8in to 10in of graphite. It has been estimated that about 110 collisions with graphite atoms take place during this slowing-down process. Very careful purification of the uranium and of the moderator proved necessary to reduce the number of cases of non-fission capture of neutrons by impurities. Calculations have shown that the maximum permissible amount of

impurities are a few parts per million in the uranium or the moderating material.

The Heavy Water Reactor

Because of the remote possibility that graphite-moderated nuclear reactors would not be able to produce the fissionable material required for the "Manhattan" Atomic Weapon Project, much thought was given in 1943 to the construction of a heavy-water-moderated reactor. Consequently, the production of heavy water in appreciable quantities was undertaken at an early stage in the development of the atomic energy programme in the United States. Measurements performed on heavy water with the use of the graphite-moderated pile during the summer of 1943 proved the feasibility of a heavy water reactor and produced sufficient information to permit its construction. On May 15, 1944, the heavy water reactor at the DuPage County site of the Argonne National Laboratory was operated initially at low power and thus became the world's first heavy water nuclear pile.

In comparison with graphite-moderated reactors, the heavy water reactor (Fig. 4) is rather small. It consists of an aluminium tank, 6ft in diameter and 8ft 10in high, which is filled with approximately 6 tons of heavy water, in which are suspended 120 uranium metal rods, 1·1in in diameter and 6ft long. The uranium rods, whose total weight is nearly 3 tons, are arranged at 5¾in centres (Fig. 3) to form a square lattice. Heavy water is more effective than graphite in slowing down neutrons and does not absorb neutrons as readily as graphite does. To remove the heat created in the fission process, the heavy water is circulated through a heat exchanger. Thus, it serves as a cooling agent as well as a moderator. The reactor tank rests on a 2ft layer of graphite blocks supported by the concrete piled foundation. The graphite reflects the neutrons to the reactor core. In addition to this neutron reflector on the bottom, the sides are provided with a reflector of equal thickness. A 4in shield of lead-cadmium alloy surrounds the reflector and fits closely against a thick concrete shield, which encases the entire reactor. The lead-cadmium alloy protects the concrete from exposure to neutron and gamma radiation. A 1ft shield of lead bricks is placed on top of the graphite reflector and is continued over the top plate of the reactor tank. Between the bottom of the lead cover and the top plate of the reactor tank there is a thin layer of cadmium metal. Neutrons escaping from the uranium section of the reactor are slowed down by collisions with atoms in the heavy water and are then absorbed by the cadmium shield.

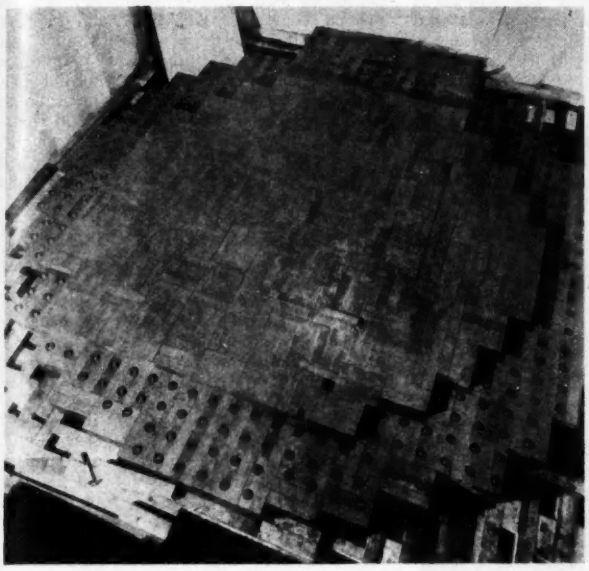


Fig. 2—Core of Uranium-Graphite Reactor

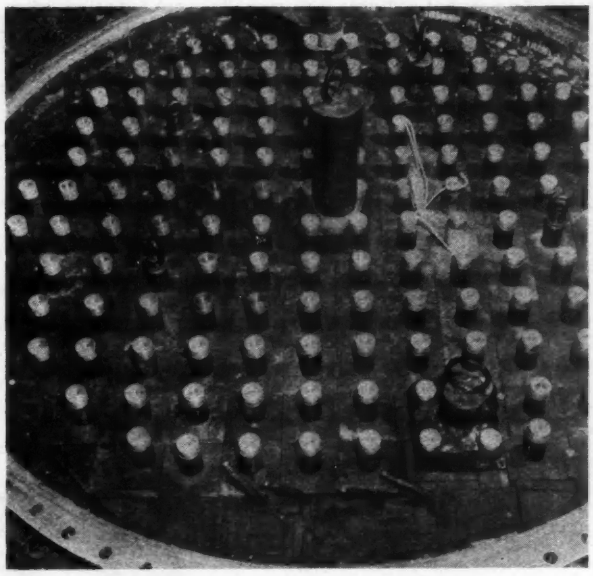


Fig. 3—Core of Heavy Water Reactor

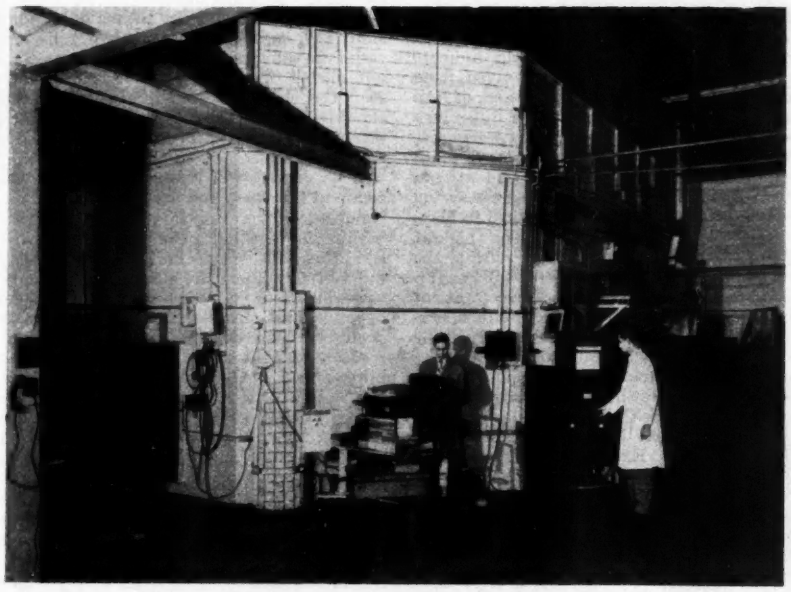


Fig. 4—Heavy Water Reactor

This absorption of neutrons causes the cadmium to emit gamma rays, which are, in turn, stopped by the lead shield. Thus personnel are protected from neutrons by the cadmium and from gamma rays by the lead during the loading and unloading of fuel. The thick lead shield at the side and bottom contains copper tubing for circulating cooling water to remove the heat generated in the shield and in the graphite. The space between the heavy water and the cover of the tank is filled with helium. This inert gas replaces the air which would normally be present, and which has to be kept out of the system as its moisture would be condensed inside the reactor tank and would dilute the heavy water. Another objection to the use of air is due to radiation bombardment of air, resulting in the formation of nitric acid. Two blower pumps circulate the helium and any dissociated heavy water through a cooler and through a catalyst chamber. Under neutron bombardment heavy water molecules dissociate to form oxygen and heavy hydrogen and these gases are recombined in the catalytic chamber and returned to the reactor tank.

The reactor core is surrounded with a biological shield, which is in the form of an approximately octagonal concrete prism 13ft high and having walls 8ft thick. The top of the reactor is shielded with a 4ft layer of blocks of wood and steel weighing 70 tons. Only five of the eight faces of the reactor are visible because the cooling machinery room encloses within itself three of the faces. Eleven openings, closed by removable shielding plugs, penetrate the biological shield and the graphite reflector to provide facilities for measuring the neutron intensity of the reactor, for exposing materials to neutrons and for permitting the passage of beams of radiation from the reactor. Four of these openings contain ionisation chambers used in operating the reactor. The other seven may be opened to permit the passage of beams of neutrons or may be used to introduce materials into the reflector near the reactor tank for making them radioactive by exposure to neutrons. On the east face of the reactor there is a large opening, approximately 30in square, also used for irradiating materials by neutron exposure. The opening contains twenty hollow graphite stringers to hold materials to be irradiated.

A thermal neutron column carries a beam

of slow neutrons from the reactor. The column consists of a stack of ordinary graphite blocks, 5ft square and 7ft 8in long, extending back to the neutron reflector. The end extending through the concrete shield is covered with a cadmium curtain and a 2ft lead and iron shield in which an 8in square opening is provided. Neutrons created in the reactor are slowed down, to be in equilibrium with the room temperature or thermal agitation of the graphite molecules, by repeated collisions with graphite atoms. When needed in research experiments, they leave the reactor through this opening. The size of the opening may be altered by changing the size of the cadmium cover.

In many experiments materials made radioactive in the reactor must be removed from the reactor in a short time. To speed their insertion into and removal from the reactor, materials which lose their radioactivity after a few seconds travel in a pneumatic tube arrangement built into one of the eleven openings passing through the concrete shield. Materials to be irradiated are placed in small plastic cylinders and are shot in and out of the reactor. Helium gas is used to move the samples in and out of the reactor.

In addition to the eleven openings in the sides of the reactor an opening known as the central experimental thimble extends from the top of the reactor into the heavy water (Fig. 3). This opening has been made by extending a 4in aluminium pipe from the centre of the top shield, through the tank lid, and down to within a foot of the aluminium tubes, through which various samples may be lowered into the centre of the reactor for exposure to fast and slow neutrons. Thirty-two irradiations may be performed simultaneously by the use of this facility.

The heavy water reactor is equipped with two control rods, two safety rods, and three shim rods. All contain cadmium metal so that they will absorb neutrons and stop the chain reaction. The safety and control rods are each made up of a 3½in tubular sandwich of $\frac{1}{16}$in cadmium placed between two aluminium tubes. These rods are hinged to the bottom side of the cover of the heavy water tank. When they are in the "in" position they are hanging at about 30 deg. from the vertical position. When the rods are in the "out" position they are suspended almost horizontally above the water in the tank. The rods have a total movement of 60 deg. The shim rods are contained in aluminium tubes and are mounted inside the tank in a vertical position with one end of the rods penetrating through the top of the reactor tank.

The heavy water is pumped from the top of the reactor, passed through a heat exchanger situated in an adjacent pump room, and fed back into the reactor tank through an opening at the bottom of the tank. The flow rate is 160 g.p.m. Experiments have shown that this rate of flow produces only a minor ripple in the surface of the water and does not introduce any instability into the reactor. In normal operation the average temperature of the heavy water flowing from the tank to the heat exchanger is 95 deg. Fah., while the heavy water being reintroduced into the reactor is, on the average, about 7 deg. or 8 deg. cooler. There is a certain amount of radioactivity associated with the heavy water but there is no way for this activity to be transmitted to the cooling water. Should a leak occur, radioactive heavy water might enter the light water cooling system but Geiger counters inserted in the cooling line would immediately reveal the presence of radioactivity and the necessary steps to prevent further loss of the valuable heavy water would be taken.

The controls for operating the reactor are situated in a room near the north face of the reactor. To start the reactor the operator merely pushes a button and the 32 lb safety rods are pulled out of the reactor. By pressing another push button, one of the two motor-driven control rods is removed. To shut off the reactor the operator causes the safety rods to fall back into vertical positions inside the tank. If the power of the reactor should become too great, if some of the controls should fail to function, or if there should be an interruption in the electrical power supply, the safety rods automatically fall into the "in" position by gravity and the reactor shuts down immediately. As a further emergency measure a large, quick-opening valve can discharge the moderator by gravity to a storage tank. The shim rods are usually not moved but are allowed to remain fairly constant in day-to-day operation. Occasionally, however, they are adjusted when materials are irradiated in the reactor. For example, if a material possessing great ability to capture neutrons is placed into the reactor for irradiation, the shim rods will be withdrawn to reduce the amount of neutron capture by the cadmium in the shim rods, thus making more neutrons available for capture by the newly-introduced sample. Conversely, in some instances, the rods may have to be lowered deeper into the water in order to increase the number of neutrons captured.

The Homogeneous Reactor

Plans for the "water boiler," a homogeneous chain reactor using as fuel an enriched uranyl salt solution in water, were started in August, 1943, at the Los Alamos Scientific Laboratory at Los Alamos, New Mexico. The original water boiler design for a low-power reactor (LOPO) was completed in November, 1943. It was decided to build this device before attempting the later model reactor of higher

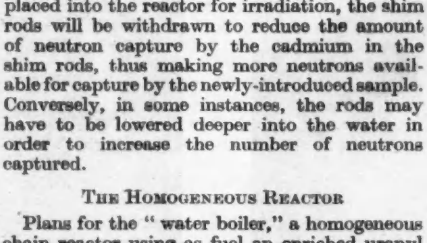


Fig. 5—Core of Los Alamos Homogeneous Reactor

power. In the low-power unit the shielding and cooling problems were eliminated. At the same time, its operation would indicate to what extent gases might be evolved from fission fragments and decomposition of the water and would reveal unforeseen difficulties in keeping the salt solution critical. A separate building for LOPO was erected at a place remote from the main technical site at Los Alamos. Assembly proceeded during the spring of 1944 and the system became critical in May, 1944, with 1·2 lb of U-235. The highest power to which LOPO was run during the several months of its existence was about 50 milliwatts, which raised the temperature to about 94 deg. Fah. In view of the successful operation of LOPO, it was decided to construct the high-power unit, which would provide a more intense neutron source. The high-power reactor (HYPO) reached the chain reaction stage in December, 1944, with about 1·8 lb of U-235, although the normal loading contains about 1·9 lb of U-235. Except for minor design changes, HYPO, as originally constructed, has operated successfully for several years.

The Los Alamos water boiler has been used primarily for physical experiments requiring a concentrated neutron source. It is the smallest and most economical type of chain reactor which has, so far, been built. The peak power of HYPO is about 6kW, representing a neutron flux of about 300 billion neutrons per square centimetre per second at the centre of the reactor. A slow or thermal neutron flux of the order of a billion neutrons per square centimetre per second is available for research purposes in the graphite reflector surrounding the reactor. The heart of the reactor consists of a 1ft spherical stainless steel container (Fig. 5), filled with a uranyl nitrate solution in water. The uranium in the uranyl salt contains about one part of fissionable U-235 isotope to six parts of non-fissionable U-238, compared to ordinary uranium, which contains one part of U-235 to 140 parts of U-238. Surrounding the container is a reflector, or tamper, consisting of an inner core of beryllium oxide supplemented by a shell of graphite. The reactor and tamper occupy a cube of about 5ft side. A considerable amount of shielding is necessary to protect operating personnel. The shield around the entire assembly consists of 4in of lead, $\frac{1}{16}$in of cadmium, and 5ft of poured concrete. At the front or working face of the reactor a square tunnel pierces the shield. This tunnel was plugged with graphite to form a graphite thermal column and a number of ports for experimental irradiations were placed in the column and the tamper. A 1in tube also extends through the shield, tamper and through the reactor sphere itself, permitting materials to be irradiated at the highest neutron flux level.

Because of its low power, LOPO required no cooling system. In HYPO, however, a six-turn cooling coil of ¼in tubing and having an effective length of 157in is wound in the form of a helix inside the sphere. Water is pumped through the cooling system at a rate of about 40 g.p.h., which is sufficient to permit continuous operation at 6kW. After passing through the reactor, the cooling water is retained for a short time in a tank within the shielding to permit short lived induced radioactivity to die down before it is released. When operating, the water in the fuel solution is decomposed by the highly ionised fission products, forming about ½ cubic foot of hydrogen and oxygen gas per hour. Since this chemical mixture is extremely explosive and also since highly radioactive gases are produced in fission, some means of diluting and flushing out these gases is required. This is accomplished by means of a double inlet-outlet tube welded to the top of the sphere. Air is pumped through the inner ¼in tube and is exhausted through the outer ¾in tube. The inner tube may be raised or lowered so that it acts as an indicator of the solution level. Furthermore, by leading the gas from the outlet tube through test equipment, rapid analysis of the boiler gas may be made. Thermocouples for measuring temperatures are placed in a tube extending into the centre of the sphere and are also connected to the water inlet and outlet tubes.

HYPO is controlled by means of a cadmium shim rod, two cadmium control rods, and a cadmium safety rod. The latter always remains out during operation, since it is used only to stop the chain reaction in case the intensity should become too high. For additional safety, the two control rods are designed with a release mechanism so that they can stop as well as control the reaction. If both control rods and the safety rod are dropped at the same time the neutron intensity falls by 85 per cent within one second. Under normal operating conditions the water boiler is self-regulating, due to the temperature effect. As the temperature increases the volume of the solution expands and the reactivity per unit volume declines. This automatically slows down the reaction so that under normal conditions it is impossible for the reactor to get out of control. If the control rods are pulled out too rapidly, however, the heat release could possibly be non-uniform through the solution. For very short times, such as $^1/_{50}$ second, local hot spots might arise, in which the solution would vaporise before the increased temperature had time to control the activity. In such cases the control rods would drop automatically to stop the reaction before serious damage to the reactor could occur. The neutron flux is measured continuously by means of an ionisation chamber, coated with uranium 235. The U-235 atoms in the coating undergo fission when hit by neutrons and the highly charged or ionised fission products can be detected by the chamber. The detection circuit leads into a very sensitive galvanometer, in which the amount of electric current registered is proportional to the neutron flux. Independent U-235 chambers are used to trigger the safety and shim rods, which drop whenever a predetermined intensity is reached. Extremely accurate control of the water boiler requires

almost continuous adjustment of the control rods. Though this can be done manually, an automatic pilot has been designed to maintain the power at any fixed level.

All operations necessary to starting, running and stopping HYPO are performed from a control desk situated in a room adjacent to that containing the reactor. Indicator lights and various warning signals aid the operator in controlling the reactor and in tracing faults. The typical operating procedure for HYPO is as follows :—

Readings are made and recorded of the U:235 ionisation chamber power indicator, solution level and sphere temperature. The flushing air and cooling water are turned on and the direct-reading galvanometer is set on maximum sensitivity. The control rods are checked for "in" position. The safety rod is raised and the first control rod slowly raised while the galvanometer deflection is observed. After the first control rod is at the "out" position the second rod is raised until the desired operating level is reached on the galvanometer. The automatic pilot can then be switched on to maintain constant power. The reactor responds very rapidly to changes in the control rod position, and they may be made as rapidly as the operator desires. An experienced operator can bring HYPO up to full power in a few seconds. With an inlet water temperature of about 45 deg. Fah. and 1·9 lb of U-235 in the boiler, HYPO could run continuously at 5·5kW without exceeding a solution temperature of 185 deg. Fah., if this should ever become necessary. At this power level some excess reactivity is available for experiments on materials which absorb neutrons. After reaching a constant operating temperature corresponding to a power level of 1kW or more the reactor will maintain an operating level constant to within a few tenths of 1 per cent.

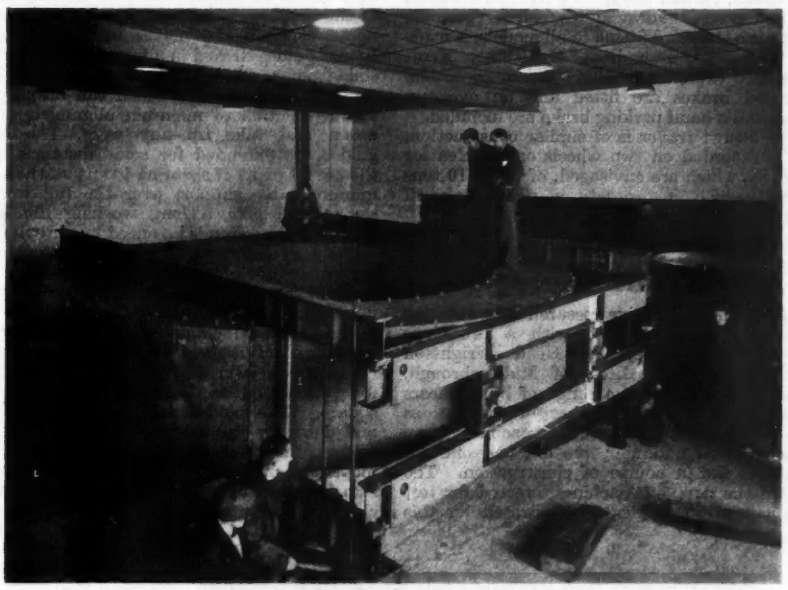
At Los Alamos a small chemical laboratory was erected near the HYPO site to recycle the fuel solution and to remove fission fragments. An underground stainless steel conduit was installed to carry the uranyl nitrate solution from the reactor to the chemical apparatus.

Synchro-Cyclotron for Liverpool University

Our illustration shows the first of two large magnet coils for a synchro-cyclotron which is being installed in the nuclear physics laboratory of Liverpool University. The synchro-cyclotron which is intended for experimental work in nuclear physics is designed to accelerate protons to an energy of about 400MeV (million electron volts). It will also be capable of accelerating deuterons and other positively charged particles, though the energy of these particles will be correspondingly reduced. In addition, it will make possible the study of artificially produced mesons.

The overall dimensions of the magnet are 32ft by 22ft by 13ft, and it weighs nearly 1800 tons. The central magnetic field will be about 18,000 gauss, the magnet air gap being 15in long and 156in in diameter. A direct current generator driven by a synchronous motor will supply the total power of 840kW required to excite the magnet.

There will be two magnet coils, the first of which is already installed, as illustrated. Each coil is cylindrical in form and is wound with a water-cooled aluminium conductor, the total weight being 30 tons and the diameter 20ft. For the journey by road from Trafford Park to Liverpool the magnet was encased in a steel girder frame weighing about 10 tons.



Magnet Coil for Synchro-Cyclotron at Liverpool University

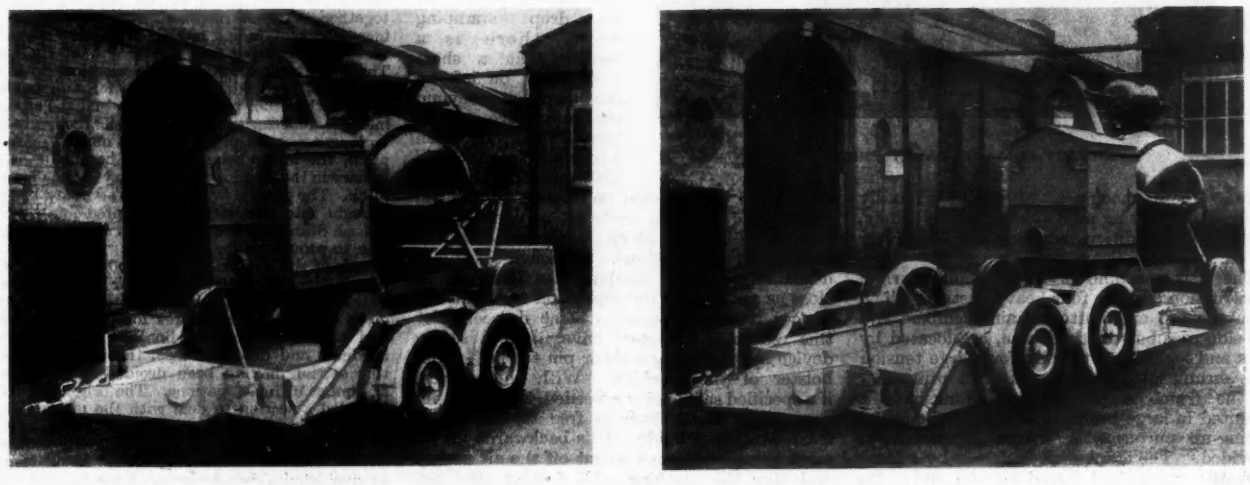
It is expected that the synchro-cyclotron will be completed in 1952. It will be the largest installation of its kind in Europe and one of the largest in the world. The design and construction of the complete unit, which includes water purification and degassing plant, radio-frequency apparatus and substation equipment, is being undertaken by the Metropolitan-Vickers Electrical Company, Ltd., Trafford Park, Manchester.

A Trailer with Retractable Chassis

To facilitate loading and unloading procedure a trailer has been developed the chassis of which can be lowered to the ground and retracted by means of an internal hydraulic system. The trailer, which is manufactured by the Ibbett Engineering Company, Ltd., Bedford, is available in 15 cwt, 30 cwt and 3-ton versions, and we were able to see, at a recent demonstration, the loading and unloading of the two heavier units.

The 3-ton trailer, which is illustrated below has an overall length of 10ft 9in, a width of 5ft 7½in, and a tare weight of 18½ cwt. The chassis is a rigid all-welded structure, with high-tensile steel channels placed longitudinally and reinforced with tubular steel cross members. Vertical box section members welded to the chassis support the body sides, the top edges of which are also formed into box sections. The ramp door can be removed, but, if lowered, it is suitably tapered to accommodate the 3¾in depth of floor, which can be of either plate or wooden construction.

Each of the four wheel stub axles is mounted in large diameter tapered roller bearings and is carried on a horizontal arm to the other end of which double quarter elliptic springs are rigidly fastened perpendicularly; the fulcra of the units thus formed are mounted upon the ends of the two transverse axles. The upper ends of the four springs on each side are linked through pinned joints by a member, which remains horizontal. The hydraulic jacks are connected to each of the forward upper joints of this pinned suspension linkage and, at their other ends, to the chassis. Mechanical locking arms engage with the rear upper joints of the linkage when the chassis is raised, thus relieving the hydraulic system of any load when the



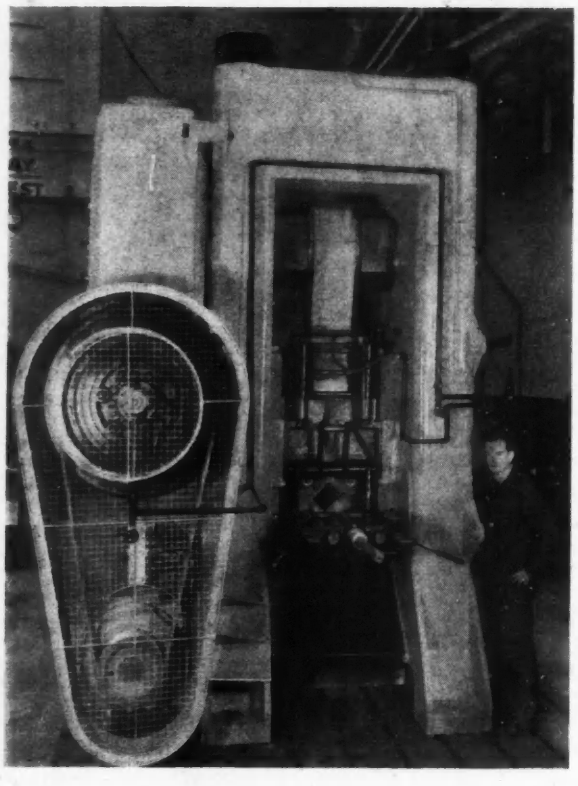
3-Ton Trailer, Loaded (Left) and with Chassis Lowered (Right)

retraction is complete. The locking arms themselves are hydraulically actuated, and, when raised out of engagement, allow the linkage to rotate and the chassis to drop under its own weight. The chassis is raised by operation of the hydraulic hand pump, which, when loaded, requires an effort of some 50 lb. The locking arms engage automatically. The hydraulic equipment of this Green-Ibbett suspension system is supplied by Power Jacks, Ltd., and the hydraulic tow hitch coupling, which is a standard fitting to all models, is made by Brunswick Foundries, Maidstone, Kent. Internal expanding 10in diameter cable-operated brakes are fitted and an over-run brake and a hand parking brake are included.

The 30 cwt trailer is of similar construction, but is mounted on two wheels only. Heavier versions, which are envisaged, of up to 10 tons capacity, will incorporate a power take-off for the hydraulic system.

A Billet Shear

FOLLOWING extensive research into shearing problems and experience with a prototype machine in service, the Head Wrightson Machine Company, Ltd., of Middlesbrough, is now manufacturing a range of billet shears which incorporate a number of innovations Up to the present three 3in machines have been supplied and now five 5in and one 4in machines are in course of construction. The first of the new 5in machines, erected for test at the maker's works, is illustrated on this page. These machines, although primarily designed for cutting mild steel and alloy billets, in the cold condition, can be used effectively for cutting hot billets.



EXIT END OF BILLET SHEAR

The new machine is of particularly rigid construction and the four heavy castings which form the top and bottom main members and the side members of the frame, are located by keys and locked together by four large tension rods shrunk into position. In the top member of the frame a forged steel crankshaft is mounted in large bronze bushes and, for initial setting-up purposes, a wedge adjustment is provided. The crankshaft is driven by a large diameter wormwheel keyed to one end. On an extension to the shaft of the worm drive is a heavy flywheel, which runs on roller bearings, and is driven through multiple vee belts from a foot-mounted motor on the side of the machine. The flywheel drive to the worm-shaft is taken through an air-operated multi-plate clutch.

The crankshaft actuates a cast steel pitman, the lower end of which is radiused and engages in a recess of similar shape in the top apron of the machine. This apron, which carries the upper shear blade, moves in long phosphor bronze guides carried in abutments on the main slide frames. These guides are backed by long, tapering wedge-pieces, which can be adjusted through screws to maintain alignment of the apron and take up any wear. The apron guides are extended for some distance below the actual point of shearing to ensure the maximum possible support over the full working stroke and give a long working life. The weight of the apron is balanced by air cylinders.

The cast steel bottom bolster of the machine carries the lower shear blade and a heavy vee-grooved support roller, which forms the bottom unit of the hold-down. This hold-down consists of a large clamping block mounted on two large adjustment screws, through which its height is adjustable to make it adaptable for gripping billets of different sizes up to 5in square. The hold-down block is moved up and down by the sideways movement of two wedges mounted on a cross ram, which is moved by single-acting air cylinders. When the ram is forced over by its air cylinders in the clamping operation, the wedges move across sloping upper faces on the hold-down block screws to lock a billet between the block and the vee-roller ready for shearing. A particular merit of the hold-down design is that it automatically comes into operation to clamp firmly a billet before shearing commences. In the sequence of operations, when the machine operator has depressed his control pedal, air is first admitted to the hold-down cylinders before engaging the clutch drive. At the end of the cutting stroke a cam on the crankshaft automatically exhausts the clutch air cylinder, the hold-down is released and a brake is applied to stop the pitman in the top dead centre position in readiness for the next cut.

When a machine is used for cutting-up billets continuously into short pieces, as for drop stamping work, there is a danger that a short piece may be left on the bar which is beyond the inner face of the hold-down. In such a case the billet would tilt on the shearing stroke and there would be exerted on the top apron and bottom bolster a considerable "wedging" force, which might cause serious damage to the machine. Although the hold-down on the new machine has been set as close as possible to the top apron to avoid this danger it still remains to some degree. For this reason the makers have fitted a safety device incorporating a shear pin to the bottom bolster of the machine. With this device, if a specified safe load is exceeded, the safety pin shears and the bolster is free to slide back clear of the top blade. This backwards movement actuates a valve to cut off the air supply and stop the machine. No further cuts can be made until the short billet length has been removed and the bolster replaced and fitted with a new shear pin. The designers state that this resetting operation takes about ten minutes to complete.

The machine is fitted with a strongly constructed back gauge, which has a quick-action lever adjustment in 3in increments and means of fine screw adjustment for intermediate lengths. As shearing of the billet begins the front of the gauge is tilted down to allow the cut piece to fall clear of the blades.

All of the principal moving parts of the machine are mechanically lubricated from a central system and it is designed to give easy access to all necessary parts for maintenance and inspection purposes.

The three sizes of shear now being built have the following characteristics for cold cutting :—

Maximum size of square billet in mild steel, inches	5	4	3
Stroke, inches	4½	4	2½
Effective blade load, tons	600	384	216
Maximum cuts per minute continuous cutting	17	20	20
Length of cut using standard back gauge, inches :			
Minimum	3	3	1½
Maximum	23	24	15

For drop forging work where relatively short pieces are required in large quantities, the machine can be used for continuous cutting, in which case the speed is set to give about seventeen cuts per minute. To maintain this speed a power feed table is required. A simple changeover valve is fitted to make it possible to cut intermittently under the control of the operator.

For machines to be used only on intermittent cutting a higher speed of twenty-five cuts per minute is provided in some cases, although this is not recommended by the makers unless the shears are to be used for the bulk of the time on pieces smaller than the rating of the machine. In the course of a visit to the works of Head Wrightson and Co., Ltd., we saw the new 5in machine in operation on billets of various sizes. The clean cuts it made, free from "rags" or burrs, and the relative squareness of the cuts to the axes of the pieces were particularly noticeable.

British Standards Institution

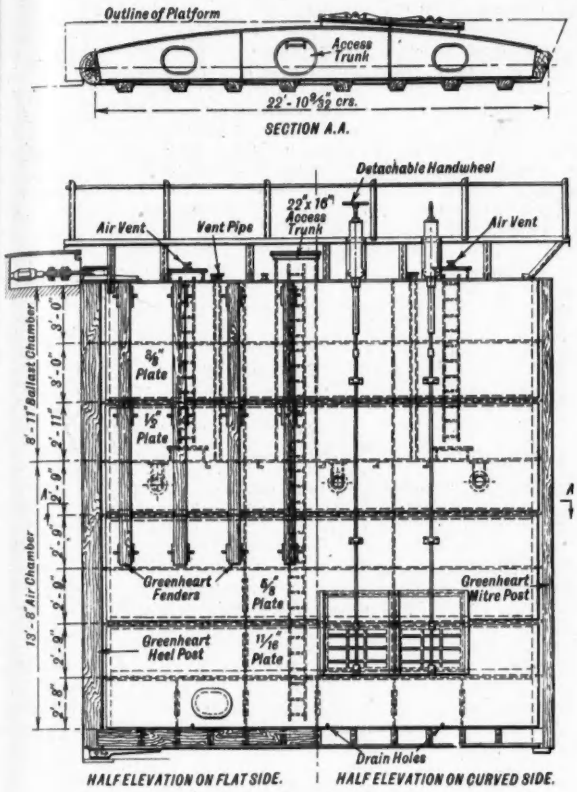
All British Standard Specifications can be obtained from the Sales Department of the Institution at 24, Victoria Street, London, S.W.1.

GEARS FOR TRACTION

No. 235 : 1951. This new standard has been drawn up to replace B.S. 235, which was originally published in 1927 to deal with gear wheels and pinions for electric tramways. In preparing the revision, care has been taken to ensure that gears made to this new standard shall be interchangeable with those manufactured in accordance with the original standard published in 1927. The ratio of the pinion addendum to the wheel dedendum is the same as that specified in the 1927 edition, and is common to all numbers of teeth, but an increased radius has been given at the root of the teeth, together with an increased root clearance; the increased root radius having been adopted with a view to improving fatigue strength of the tooth. The basic rack tooth shape is identical with that which has been adopted for the forthcoming revisions of the other gear standards, and the standard includes illustrations of this basic rack, given in both unit normal pitch and unit normal diametral pitch, the latter being included because it is customary in the traction gear industry to use diametral-pitch. The general lay-out of the standard has been brought into line with that adopted for the other British Standards for gears and it includes, in addition to provisions for the marking of the gears and details of the basic rack, two tables setting out the preparations of straight spur gear teeth and helical gear teeth of 7½ deg. spiral angle. A further section gives comprehensive figures for permissible errors and tolerances and the final section deals with hardness and depth of case, the data included in this section having been decided upon following a number of investigations. The original standard included a section to deal with the material to be used in the manufacture of these gears, but this has been omitted because the present stage of development is such that it would be undesirable to give definite specifications. Price 4s. post free.

Hay's Wharf Dock Gates

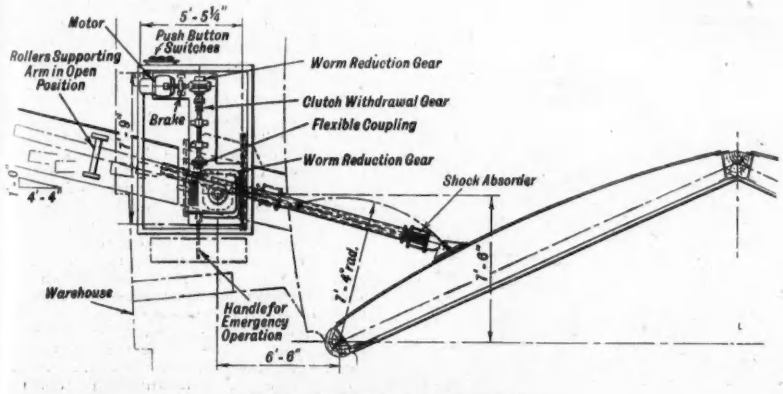
A PAIR of welded dock gates with electrically operated machinery were recently installed at Hay's Wharf. They were designed and built by [Head, Wrightson and Co., Ltd., of Thornaby-on-Tees, for Hay's Wharf, Ltd., for a 40ft entrance, each leaf weighing 26 tons. The gates were delivered to Hay's Wharf as ship's cargo and transferred by a 60-ton P.L.A. floating crane to the actual site. This crane was also employed to place the gates into position, both leaves being stepped in one side.



DETAILS OF LEAF

Each leaf of the gates, the general arrangement of which is shown in the accompanying illustration, consists of nine plate ribs, the alternate members being fitted with flange plates. The skin plating is lap jointed to the flange plates and is composed of four strakes on the flat and curved sides. The ribs are stiffened by angles, the toes of which are welded directly to the web plates and skin plating. Vertical stiffness is provided by two plate diaphragms extending for the full depth of the gate leaf. The heel post and mitre post were built from plates welded in the form of channel and joist sections respectively. A central core plate, with stiffener brackets at deck centres, is welded directly to the web of the heel post. The greenheart mitre post and sill timbers were each made in one piece, the heel post timbers being made in two pieces. Each gate leaf is held in position by two anchor rods with washer plates, one rod being set normal to the line of the dock and the other 90 deg. to it.

Our second illustration shows the gate operating machinery for one of the leaves, which is driven by a 5 b.h.p., 1410 r.p.m. electric motor. All intermediate gearing is completely enclosed, the final drive being transmitted through a vertical worm reduction gear unit to the rack pinion. A horizontal rack, which is directly connected to a rolled section, transmits the actuating force to a bracket attached to the top of the skin plating. Situated in this arm is a double-acting shock absorber. The actuating arm is housed on horizontal supporting rollers when the gate is in the open position. Limit switches are arranged to cut out the motor at the appropriate time and an overload release is provided by oil dashpots to safeguard the machinery in the event of obstruction during the course of operation. Any tendency to over-run or creep is prevented by the inclusion of an electromagnetic brake situated between the motor and the first reduction box. The operation of the gates is fully automatic by push-button control from either side of dock, provision being made for independent operation of each leaf or the simultaneous operation of the two leaves. Provision is also made for emergency hand operation in the event of a failure in the electricity supply.

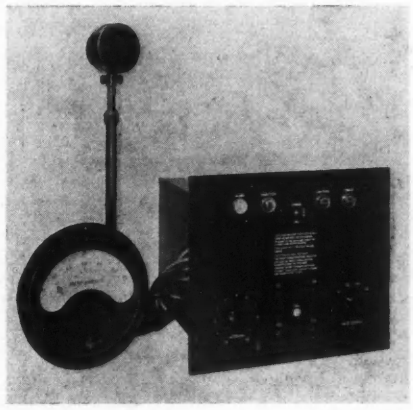


GATE OPERATING MACHINERY

A Feed Controller for Pulverised Fuel Mills

PULVERISED fuel for modern draught-fed furnaces and boilers is processed in mills, of which there are a number of individual kinds. Coal fed continuously into such mills is reduced to the consistency of fine powder by the action of cascading steel balls within a rotating tube or drum. A characteristic of this milling process, and particularly of the continuous-feed mill, is that its effectiveness is almost entirely dependent on the correct amount of raw coal being continuously maintained within the tube. In fuel processing mills, this condition calls for careful and continuous regulation of the coal feed, a function which in the past could only be performed with any degree of accuracy by a skilled operator, who had to rely almost entirely on a highly developed sense of hearing. With the aim of devising a satisfactory system of automatic regulation, Standard Telephones and Cables, Ltd., Connaught House, Aldwych, London, W.C.2, recently investigated the possibility of emulating the work of the skilled mill-feed operator by acoustic and electrical means.

In fuel processing mills, the rate of feed required is dictated by a number of variable factors, not least of which are the boiler or furnace requirements: too high a rate of feed quickly results in a condition where the tube becomes choked and may even have to be cleared by hand. To be effective, therefore, any method of automatic feed control must be based on the actual, and not estimated, amount of raw coal within the drum. Since it is not possible to make any assessment of this quantity based on the amount of coal being fed into the mill, or its output, an acoustic feed controller would have to be designed to determine the actual contents of the mill from the noise level of the cascading coal and balls in contact with each other and with the walls of the drum. As with the human ear, this calls for very fine distinctions in noise level taken at a reference point in the immediate vicinity of the drum.



ACOUSTIC CONTROLLER FOR P.F. MILL FEED

The basic apparatus evolved for this purpose is illustrated herewith. It is based on a microphone (which has to be adequately protected against dust and dirt) placed immediately beneath the drum. The microphone is connected by cable to the main controller unit, which is set up at any desired distance from the mill. The output stage of the controller unit comprises a series of pads for lining-up purposes, an amplifier and a high-pass filter, the function of which is to segregate the significant high-frequency noises emanating mostly from inside the drum from the low-frequency noises associated chiefly with the external gearing and drive of the mill itself. As a matter of interest, the most significant noise frequencies have been found to exist at about 4 kc/s. They give a noise discrimination of some 14 decibels between the full and empty condition of the tube, as compared with about 3 decibels, which is the best discrimination possible when considering the overall noise frequency spectrum of the mill. The low figure of 3 decibels which applies to the aural method of control explains why the operation demands so much skill and why the effectiveness of the control is liable to be affected when the operator has a cold in the head.

The output from the amplifier-filter stage of the controller is used to actuate a sensitive relay adjusted to operate in accordance with

fluctuations in noise above and below a set figure corresponding to the optimum amount of coal in the tube. This relay serves to provide, through suitable heat coils and relay trains, a means of altering the speed of the feed motor or, alternatively, for manual control purposes, of actuating a suitable gauge to afford visual indication of the contents of the tube mill.

A Bright Normalising Furnace

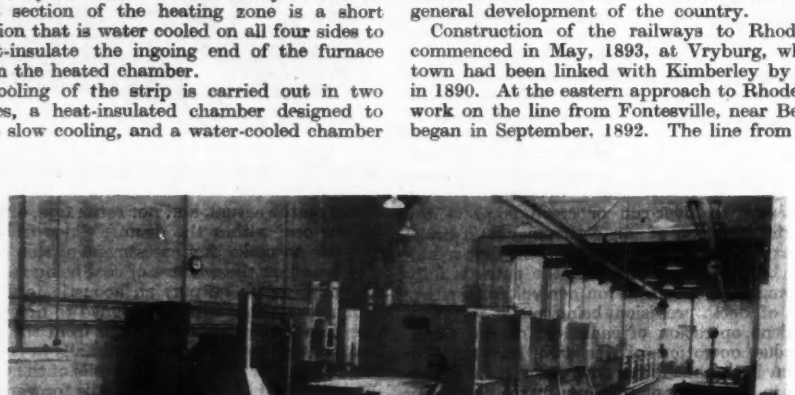
For the bright annealing of steel strip in coils, the Effingham Steel Works, Ltd., of Sheffield, has for many years used vertical cylindrical furnaces made by the General Electric Company, Ltd. Recently, however, a new G.E.C. furnace has been installed for the continuous treatment of steel strip in lengths, in an atmosphere of partially burnt town gas. Our illustration shows the input end of the furnace, which operates with a roller hearth and is approximately 120ft in length, is rated at 220kW and has a nominal output of 10 cwt of strip per hour. The strips to be normalised are placed side by side across the furnace, which has a loading width of 18in. All thicknesses of material up to ¼in are treated and the strips emerge at the unloading end with surfaces unblemished by oxidation.

To secure precise control of temperature and economise in power and atmosphere consumption the furnace is divided into several zones. First, there is the heating zone, which has three sections of equal length, each rated differently, the section with the highest rating being nearest to the furnace entrance. All the heating elements, however, are identical, to simplify maintenance work. The temperature in each section is independently and automatically controlled. Immediately before the first section of the heating zone is a short section that is water cooled on all four sides to heat-insulate the ingoing end of the furnace from the heated chamber.

Cooling of the strip is carried out in two zones, a heat-insulated chamber designed to give slow cooling, and a water-cooled chamber of sufficient length to enable the charge to be handled on emerging from the exit. Water is circulated in all sides of this final zone, with separate control of the supply to the top and bottom panels. The top panels can be easily removed for inspection purposes. At both ends of the furnace there is a combined atmosphere chamber and hood, with a flap to reduce to a minimum loss of heat to atmosphere and also to prevent the entry of air. At the top of the hoods are short pipes fitted with gauzes, so that gas issuing from the ends of the furnace can be burnt.

The rollers which form the hearth of the furnace are driven by a squirrel-cage induction motor through a variable-speed gear. A wide range of speeds can be obtained by moving a lever, and push-button control is fitted for starting, stopping and reversing the drive. The spacing of the rollers is varied according to the temperatures of the various zones, so that the charge is rigidly supported at all stages of treatment. All the bearings in the heating and cooling zones are water-cooled and special provisions are made for expansion of the heated rollers and for any re-alignment which might become necessary through movement of the outer casing of the furnace due to heat.

As a safeguard against spoilage of the charge during a power cut, provision is made for a 3 h.p. petrol engine to continue to drive the rollers. The engine is directly coupled to the rollers via a reduction gear, and there is a two-way clutch to effect a quick change-over and to ensure that the normal and auxiliary drives cannot be in mesh together. The furnace is supplied with the necessary gas atmosphere by G.E.C. gas plant capable of delivering 1000 cubic feet per hour. Electrical supplies are drawn from 440V, three-phase mains.



Input End of Furnace

South African Engineering News

(From our South African Correspondent)

Rhodesia Railway Developments

An interesting history of development has been issued in the form of a bulletin by the Rhodesia Railways, which form part of the communications system planned by Cecil John Rhodes through the length of Africa from Cape to Cairo. The project did not materialise, but under his influence railway communication to and from Rhodesia was established at a rate far in advance of the general development of the country.

Construction of the railways to Rhodesia commenced in May, 1893, at Vryburg, which town had been linked with Kimberley by rail in 1890. At the eastern approach to Rhodesia, work on the line from Fontesville, near Beira, began in September, 1892. The line from the south to Bulawayo, was opened in November 1897, and that from Beira to Umtali in February, 1898. The Umtali-Salisbury link was completed in 1899 and the Salisbury-Gwelo-Bulawayo section in 1902. The line from Bulawayo to the north reached the Victoria Falls in 1904, Broken Hill in Northern Rhodesia in 1906, and the border between Northern Rhodesia and the Belgian Congo in 1909. The track is built throughout to the standard South African 3ft 6in gauge. The system extends from Vryburg in the Union of South Africa, through the Bechuanaland Protectorate, to Bulawayo, the southern section being operated by the South African Railways on behalf of the Rhodesia Railways, then to the Congo Border in Northern Rhodesia, and to Umtali, near the border with Mocambique territory, the total route-mileage being 2[illegible] miles. In addition, the Rhodesia Railways operate 2720 miles of road motor services in Southern Rhodesia.

Despite the many difficulties with which the Rhodesia Railways have had to contend, railway activity during the financial year ended March, 1950, was satisfactory. The tonnages hauled in 1950 and 1940 were 5,724,013 and 3,332,775, respectively, the corresponding numbers of passengers carried being 2,933,309 and 1,012,419. In 1950 the capital expenditure was £8,300,000, with a net operating revenue of £1,639,095, as compared with the corresponding figures of £2,937,116 and £1,991,456 for 1940. Some idea of the development in traction equipment may be given by a comparison between the 7th class locomotive used in 1900 and the 15th class of 1950. The former, which operated on the Matopos branch line and is now employed as a shunting engine, cost £5076, has a tractive effort of 18,660 lb and weighs 83 tons when in full working order. The latter, which is now costing over £38,000, has a tractive effort of 43,000 lb, its weight in full working order being 184 tons.

With the increasing demands being made on its services, the railway has embarked on a programme of expansion and the following details, though abridged, give some idea of what is now being done and what is planned for the future.

Main centres, such as Umtali, Salisbury, Bulawayo, Livingstone and Ndola, are receiving special attention, though not to the exclusion of other points on the system, where work is also to be undertaken. At Umtali, considerable improvements to the east end of the yard have resulted in more efficient operation and new locomotive running and goods sheds are to be provided. A new marshalling yard at Lochinvar, near Salisbury, is in partial operation and will be extended. The main line and connections to the yard are provided with modern colour-light signalling. There is also a scheme to divert the approach from Shamva and Sinoia from the northern and eastern suburbs of Salisbury to a route which will connect Mount Hampden junction with the west end of Lochinvar yard. At Buluwayo a scheme of reconstruction is in hand.

Que Que and Gwelo are to have additional traffic facilities in due course and new yards are planned for Ndola. Deviations between Wankie and Dett, Kafue and Lusaka, and on the West Nicholson branch and at Hunyani are in hand or are under investigation. Centralised train control, which will assist in developing the capacity of the single-track system, should be in operation between Heany and Gwelo within the next few months. Mechanical and colour-light signalling are being introduced on an extended scale.

Consequent on the expansion, there has been a steady growth in both European and African personnel. The figures for the line north and east of Bulawayo show the increase in the past ten years. In 1940 Europeans employed totalled 3319, of whom 372 were on active service. This number rose to 590 in 1950. Coloured staff increased in number from forty-two to ninety-two in the same period, and African staff from 9259 in 1940 to 15,776 in 1950.

Tables for Solving Continuous Beams.—The system of tables for solving continuous beam problems developed by A. P. Skayannis, was first published in Greek in 1949. The second edition, in English, is now available; it is entitled "System of Tables for Quick and Accurate Solving of Any Continuous Beam," and may be obtained from Lange, Maxwell and Springer, Ltd., 41–45, Neal Street, London, W.C.2, the price quoted being 2 U.S. dollars. Explanations and instructions for using the tables are given and the author claims that by their use continuous beams may be solved more quickly and as accurately as by the Hardy Cross method. The tables are valid for any number of spans; different lengths of span; constant moments of inertia in each span, but varying from span to span, and for uniformly distributed or concentrated loads.

Industrial and Labour Notes

British Overseas Trade

Final figures relating to Britain's overseas trade in February, which were published at the end of last week, show that exports of United Kingdom goods were valued at £175,374,128, compared with £214,389,636 in January. February contained only twenty-four working days, compared with twenty-seven in January, but even if allowance is made for the smaller number of working days, the rate of export in February was 8 per cent less than in January or in the fourth quarter of 1950.

Exports of manufactured goods in February amounted in value to £153,302,638. This group included iron and steel and manufactures thereof, valued at £11,508,469; non-ferrous metals and manufactures thereof, valued at £6,889,578; electrical goods and apparatus, valued at £5,948,473; machinery, valued at £23,810,377; and vehicles (including locomotives, ships and aircraft), valued at £31,062,083. The Board of Trade says that February exports of cars and chassis amounted to 27,116 units, valued at £8,300,000, bringing the average for January and February to 30,617, or 8 per cent below the 1950 monthly average. Commercial vehicles exported in February numbered 10,343, compared with 13,663 in January.

February imports were valued at £247,775,652, compared with £297,931,271, the major part of the reduction being caused by smaller imports of raw materials. Taking January and February together, however, the value of imports of raw materials was 48 per cent above the 1950 average, but, the Board of Trade observes, that increase was accounted for entirely by higher prices.

The T.U.C. Interim Report

The Trades Union Congress has just published, in a pamphlet entitled "What the T.U.C. is doing," an account of its activities since the publication, last September, of its General Council's annual report. This interim report deals with a number of matters which have been examined by the T.U.C. General Council and its Economic Committee in recent months.

It mentions, for example, "constant scrutiny" of profits and prices, and comments on "changes both for the better and for the worse in the economic situation." On the one hand, the report says, production and productivity have improved, but, on the other hand, wholesale prices have risen sharply, partly as a result of rearmament and stockpiling and partly as a result of devaluation. Profits and dividends, it is stated, have continued to increase, while there has been a noticeable rise in wage rates. The report then proceeds to record discussions with the President of the Board of Trade on the subject of price controls and profit margins.

Later in the report it is stated that "because of their key importance in the economic life of the nation, the industries under public ownership call for almost continuous attention." The T.U.C. Economic Committee has begun a review of the financial structure of the nationalised industries, which it was agreed at last year's Congress should be undertaken. It is acknowledged that the financial structures of the nationalised industries vary widely, and "top priority" is being given by the Economic Committee to the transport industry, "mainly because the deficit attracted much attention to the compensation payments for the railways." The Committee's preliminary findings on the finances of nationalised transport have been sent to all the unions in the industry which were invited to submit their written observations. A similar document on the coal mining industry has been sent to the unions concerned.

The report also deals with the pace of industrial progress, saying that, though the main efforts to attain a higher industrial efficiency must come from within each industry, "the T.U.C. is constantly searching for new ways to be helpful to its unions in this work." Examination of the fuel situation, the T.U.C. declares, has served to underline the need for the electricity, gas, coal and oil industries to work more closely together. Organised as competing services, the report observes, they cannot separately be expected to cope with problems of the "peak" in midwinter. Indeed, the T.U.C. suggests, the fact that they are self-contained services adds to the disorganisation at such times. What is wanted, the T.U.C. feels, is not so much a national policy for electricity, or gas, coal or oil, as a national policy for fuel.

The Coal Situation

In the week ended March 17th, the last full working week before The Easter holiday, production of deep-mined coal amounted to 4,500,300 tons. Production from opencast workings amounted to 193,700 tons, so that the total output for the week was 4,694,000 tons. Coal output in the first eleven weeks of this year amounted to 48,823,000 tons, or about 1,400,000 tons more than in the comparable period of last year. Imports of coal in the first eleven weeks of this year totalled 624,000 tons. In the week ended March 10th—the latest for which figures are available at the time of going to press—inland coal consumption was 4,502,000 tons and exports and bunkers required 209,000 tons. Distributed stocks totalled 9,712,000 tons, as against 10,412,000 tons in the comparable week of 1950.

Before the House of Commons rose for the Easter recess, the Minister of Fuel and Power, Mr. Noel-Baker, made a statement about the coal situation. He recalled the announcement, early in February, that it might not be possible during the winter months to deliver to industrial firms more than 85 per cent on the average of the coal which it had been planned they should have. In addition to economies in consumption which had been made, the Minister said that coal output had substantially improved, and it had been possible to deliver to industry, not 85 per cent, but, on the average, 95 per cent of its programmed requirements. He thought it could now be said that a high rate of delivery would be maintained during the remaining weeks before the winter period ended; that was, to the end of April.

The Minister went on to say that it remained of the highest importance, not only for this year, but for the future, that industry should make the most efficient possible use of the coal which it received. To assist in an advisory capacity on that subject, a very strong committee of experts was now being appointed under the chairmanship of Captain William Gregson, M.I.Mech.E.

Institution of Works Managers

The West Midland Branch of the Institution of Works Managers has recently set up two advisory panels, each consisting of five of its members, which will be willing to answer inquiries from other members on matters relating to incentives and also simplification and time and motion study. These panels, it is believed, will make a big contribution towards increasing the service which the branch can render to members of the Institution. Many members of the branch are in charge of leading industrial establishments in the Midlands and are experts in the manufacturing techniques used in their industries.

The third national conference of the Institution of Works Managers is to be held at the Prince of Wales Hotel, Southport, from Friday to Sunday, April 13th to 15th. The theme of its discussions is "Works Managers and the Present Economic Situation," and the intention is that the duties and responsibilities of works managers shall be examined in the light of the country's economic position.

Full particulars of the conference can be obtained from the Institution at 67–68, Chandos Place, London, W.C.2.

Industry's Problems

Speaking at the annual general meeting of the English Electric Company, Ltd., on March 20th, the chairman, Sir George Nelson, said that the two most acute problems facing industry at the moment were shortages of labour, particularly skilled labour, and materials. Sir George went on to say that, coupled with the shortage of labour in districts where production units existed, was the problem of transferring to those districts such extra labour as was required there. His company had helped to solve that problem by building more than 1000 houses of attractive design for its workpeople in different parts of the country. Sir George thought that direction of labour might ultimately be necessary and he commended to the Government that it should provide houses to attract people from other districts into the areas where labour was needed, thereby ensuring that workers were contented. Contentment, he asserted, was the basis of maximum production.

Sir George also referred in his speech to the subject of incentives and pointed out that the economic success of the nation depended on a relatively few gifted and devoted people, who gave unstinting service to both industry and their country. Industry, he said, rewarded them appropriately, but taxation took away the whole incentive. The senior people in industry were, of course, not by any means the only people so affected, for it applied equally to senior members of the Civil Service, public bodies, universities and research organisations. One realised, Sir George commented, that in view of the Chancellor of the Exchequer's need to raise further revenue, very little could be done at this time to improve the position, but he sincerely hoped that no changes would be made in taxation to worsen it.

World Steel Production

The British Iron and Steel Federation has published, in the latest issue of its Monthly Statistical *Bulletin*, some interesting details relating to world steel production in 1950. World production of steel, it says, rose last year by 17 per cent to 184,230,000 tons. The main increase, of 17,000,000 tons, occurred in the U.S.A., where production was unusually low in 1949, as a result of the autumn steel strike. Last year's output in the U.S.A. was 86,360,000 tons. According to Russian statistics, the *Bulletin* states, output in the U.S.S.R. was 27,150,000 tons, an increase of 4,000,000 tons, compared with 1949. Substantial increases in steel output were made in the United Kingdom, West Germany and Japan, but in many countries production advanced little, or even fell slightly, in 1950.

Since 1937, which was the peak pre-war year, world steel production has advanced by 50,000,000 tons and the relative importance of many steel producers has altered. The U.S.A. and the U.S.S.R., the *Bulletin* comments, retain their positions as first and second largest producers, but the United Kingdom has replaced West Germany in the third place. The big rise in American production has been possible because of the large reserve of idle capacity in existence prior to the war and the government-aided expansion of steel plants during the war years, which was carried out unhampered by enemy action. Although quantitatively unimportant compared with the U.S.A., many of the smaller overseas steel producers have, in relative terms, surpassed the American achievement by raising their outputs to more than twice the 1937 level, among them Canada, South Africa, Brazil, Mexico and the Netherlands.

The *Bulletin* adds the observation that world production of pig iron has increased at a lower rate than steel production. Whereas, in 1937, the output of pig iron was 76 per cent of steel output, it fell to 72 and 70 per cent in 1949 and 1950, respectively, reflecting the increased use of scrap in the post-war years.

Notes and Memoranda

Air and Water

ANGLO-BELGIAN AIR TRANSPORT AGREEMENT.—The Ministry of Civil Aviation states that an air transport agreement, exchanging commercial rights in United Kingdom and Belgian territories, has been initialled by representatives of the two Governments. The agreement supersedes the temporary arrangements under which air services between the two countries have operated since the war. In return for rights granted to SABENA to operate routes serving United Kingdom metropolitan and African colonial territories, British airlines have been granted reciprocal rights in Belgium and the Belgian Congo.

Miscellanea

U.S. COMMITTEE ON ATMOSPHERIC POLLUTION.—The American Society for Testing Materials has set up a technical committee to formulate methods of atmospheric sampling and analysis. It is stated that all the discussions, in recent years, on remedial measures for atmospheric pollution, there has been revealed the need for the development and acceptance of adequate methods of sampling and analysis. The temporary chairman of the committee is Dr. L. C. McCabe, chief of the air and stream pollution section of the U.S. Bureau of Mines.

GAS TURBINE TECHNOLOGY COURSES.—The two courses at the School of Gas Turbine Technology, which are intended for overseas students, have this year been arranged to coincide with the early part of the Festival of Britain and to follow the annual air display given by the Society of British Aircraft Constructors at Farnborough. Both courses are of three weeks' duration and are concerned with the theory, design and application of the gas turbine. Particulars may be obtained from the Principal, School of Gas Turbine Technology, Farnborough, Hampshire.

IRON AND STEEL ENGINEERS' GROUP.—The Iron and Steel Institute has announced that the fourteenth meeting of the Iron and Steel Engineers' Group is to be held at 4, Grosvenor Gardens, London, S.W.1, on Thursday, April 5th, beginning at 10.30 a.m. At the morning session a paper by Mr. P. E. Peck on "Electric Drives for Reversing Hot Mills" is to be discussed. At the afternoon session, beginning at 2 p.m., Mr. J. A. Kilby will present a paper on "Hot Bloom and Slab Shears." A buffet luncheon, price 6s., will be provided in the library of the Institute from 12.45 to 2 p.m.

ASSOCIATION OF BUILDING TECHNICIANS.—The Association of Building Technicians is to hold its diploma examination for clerks of works in London and Glasgow on Thursday, Friday and Saturday, May 17th, 18th and 19th. Other centres will be arranged according to demand. As in former years, the examination will cover building construction and services, building materials, quantities and estimating, land surveying, drainage and sanitation and site practice. Copies of the syllabus and application forms and previous examination papers may be obtained from the General Secretary, Association of Building Technicians, 5, Ashley Place, London, S.W.1.

CHEMICAL RESEARCH.—The Chemical Society states that its research fund provides grants for the assistance of research in all branches of chemistry; about £700 a year is available for this purpose, the income being derived from a donation of the Worshipful Company of Goldsmiths, from the Perkin Memorial Fund and from other sources. Applications for grants will be considered in November next and should be submitted on the appropriate form not later than May 1st. Applications from Fellows will receive prior consideration. Forms of application, together with the regulations governing the award of grants, may be obtained from the General Secretary, The Chemical Society, Burlington House, Piccadilly, London, W.1.

ENGINEERING CONSTRUCTION REGULATIONS.—The Ministry of Labour has issued a pamphlet, which contains a revised preliminary draft of regulations under the Factories Acts, 1937 and 1948, as to safety, health and welfare in connection with work of engineering construction. This draft is a revision of a first preliminary draft published by the Ministry in October, 1945. Many of the amendments then suggested were also relevant to the draft of a parallel code in connection with building operations. The points raised in connection with the building code have been cleared up and regulations have been made. In the meantime, the Ministry has given further thought to the parts of the code for work of engineering construction, which relate to diving operations and to work in compressed air. Many amendments of the 1945 draft are now contemplated. A pamphlet containing the revised preliminary draft has, therefore, now been published for study and consideration by persons affected, as a preliminary to conferences with the Ministry to consider and discuss points raised, before revised regulations are formally issued in draft under the statutory procedure. Copies of the pamphlet can be obtained from H.M. Stationery Office, price 1s. 6d.

COUNCIL OF INDUSTRIAL DESIGN.—The Board of Trade announces the appointment of Sir Colin S. Anderson as a member of the Council of Industrial Design. Sir Colin is a director of Anderson, Green and Co., Ltd., shipowners, and of various other companies. He is chairman of the Royal College of Arts, President of the Design and Industries Association, a member of the Arts Panel of the Arts Council, a member of the Council of the Institution of Naval Architects, and is the immediate past-president of the Chamber of Shipping.

SUMMER SCHOOL ON WELDING DESIGN AND ENGINEERING.—The British Welding Research Association, 29, Park Crescent, London, W.1, is to hold a summer school at Ashorne Hill, near Leamington Spa, Warwickshire, from Friday, May 25th to Saturday, June 2nd. The course will consist of two introductory days, during which recent developments in welding practice and the metallurgical aspects of welding ferrous and non-ferrous metals, will be discussed. There will then be five-and-a-half days devoted to general lectures on welding problems in the mornings, which will be followed in the afternoons by specialised lectures covering the following subjects: structures, pressure vessels, ships and general engineering and machinery. Among the topics to be considered are the plastic behaviour of welded structures and the application of stress analysis to ships. Finally there will be evening discussions on matters of general interest, such as weldability and distortion. Further particulars can be obtained from the Association at the address given above.

THREE MILLION FRACTIONAL HORSEPOWER MOTORS.—The three-millionth motor to be made at the Coventry works of the British Thomson-Houston Company, Ltd., was completed recently, in the presence of the Mayor of Coventry, Alderman Joseph Hyat, who visited the works during the final assembly testing and packing of this machine—one of a batch of 5000 ¼ h.p., 110V, 60 c/s, single-phase induction motors, ordered by the Canadian General Electric Company, Ltd. To mark the occasion the British Thomson-Houston Company, Ltd., has produced a booklet entitled "The 3,000,000 F.H.P. Motor," which gives some indication of the part played by the company in the development of fractional horsepower motors and their specialised applications. Apart from sewing-machine and ventilating fan drives one of the very early applications was in the production of artificial silk. To meet the needs of a leading firm of silk spinners, who stipulated that each bobbin must be individually driven, the company designed and built motors rated at 1/15 h.p. at 6000 r.p.m. By the end of 1919 the manufacture of rayon spinning motors had a permanent place in the production programme of the Coventry works. By 1924 the demand for small-power motors had become so great, especially for such domestic appliances as washing machines, refrigerators, vacuum cleaners, &c., that the company decided to manufacture a complete range of fractional horsepower motors from ⅛ h.p. to 1 h.p., and to abandon the practice of importing motors from America for resale. This decision was stimulated by the fact that the American single-phase power supply was generally at 110V and the Americans lacked experience on supplies of 200/250V. The immediate demand was for motors, built for British voltages, and suitable to be fitted on American-made machinery. From 1925, when the output of fractional horsepower motors was 1200, until the present time, the variety of these motors and the quantities produced steadily increased and during 1950 the B.T.H. production figure was nearly half-a-million.

Contracts

THE BURNTISLAND SHIPBUILDING COMPANY, LTD.' have contracted to build a motor cargo liner of 7800 tons deadweight and 15 knots speed for A/S Rederict Odfjell, of Bergen. An associated company, Hall, Russell and Co., Ltd., will build the vessel and the propelling machinery will consist of Gray-Polar geared diesel engines of 6000 b.h.p.

Personal and Business

THE NEW INSULATION COMPANY, Ltd., Gloucester, announces that, as from April 1st, it will be known as Permali, Ltd.

PETER STUBS, Ltd., Warrington, states that Mr. F. B. Watson, secretary and accountant of the company, has been appointed a director.

NEWMAN INDUSTRIES, Ltd., Yate, Bristol, has been appointed sole selling agent for the United Kingdom for Franco Tosi and Sisma diesel engines.

B.S.A. TOOLS, Ltd., states that its managing director, Mr. James E. McLaren, has been appointed a director of Birmingham Small Arms Company, Ltd.

HOPKINSONS, Ltd., Huddersfield, states that Mr. G. Sewell, A.M.I.Mech.E., chief mechanical engineer, has been appointed to the board of directors.

BRITISH INSULATED CALLENDER'S CABLES, Ltd., Helsby Works, Warrington, states that its new telegraphic address is "Bicalbest, Helsby, Warrington."

MR. SYDNEY N. DUGUID, F.Inst.F., has joined the staff of Powell Duffryn Technical Services, Ltd., to take charge of the branch office at 26, Corporation Street, Manchester, 4.

DUNLOP, Ltd., announces the appointment of Mr. F. G. Jackson as deputy works director at the Calcutta factory. He is at present manager of the central personnel department at Fort Dunlop.

MR. J. WYLLIE COATS has been appointed chairman and managing director of the General Steam Navigation Company and the Moss Hutchinson Line, Ltd., in succession to Mr. Robert Kelso, who has announced his retirement.

BROOKHIRST SWITCHGEAR, Ltd., announces that Mr. A. B. Hitch, A.M.I.Mech.E., has been appointed to the staff of Brookhirst Igranic (S.A.) Pty., Ltd., a newly-formed company, to promote the interests of Brookhirst Switchgear, Ltd., and the Igranic Electric Company, Ltd., in South Africa.

Launches and Trial Trips

NORFOLK FERRY, train ferry; built by John Brown and Co., Ltd., for British Railways, Eastern Region; length between perpendiculars 380ft, breadth over fenders 61ft 6in, depth to upper deck 34ft 9in; two sets of Sulzer diesel engines, service speed 13 knots. Launch, March 8th.

LONDON, coastal cargo liner; built by the Burntisland Shipbuilding Company, Ltd., for the Dundee, Perth and London Shipping Company, Ltd.; length between perpendiculars 201ft, breadth 36ft 3in, depth moulded to shelter deck 21ft 1in, deadweight 875 tons on 12ft 9in draught; British Polar two-cycle, direct-reversing, airless-injection, diesel engine, eight cylinders, 340mm diameter by 570mm stroke, 1280 b.h.p., electrical deck machinery. Trial, March.

L'AIGRETTE, motor trawler; built by Les Chantiers et Ateliers Augustin Normand for the Société des Pêcheries de l'Ocean à Arcachon; length between perpendiculars 32m, breadth moulded 7m, depth moulded 4·05m; M.A.N. four-cycle, single-acting, mechanical-injection diesel engine, six cylinders, 450 b.h.p. Launch, March 8th.

CITY OF SINGAPORE, cargo vessel; built by Alexander Stephen and Sons, Ltd., for the Ellerman Lines, Ltd.; length 450ft, breadth 61ft 6in, depth 32ft 9in, deadweight 10,930 tons on 28ft 2in draught; one set of single-reduction geared Parsons reaction turbines, taking superheated steam from two Babcock and Wilcox water-tube boilers, 5500 s.h.p., steam deck machinery. Trial, March 9th.

RINGERD, motor tanker; built by Harland and Wolff, Ltd., for Mr. Olav Ringdal, Oslo; length between perpendiculars 460ft, breadth moulded 59ft, depth moulded 34ft 10in, deadweight 12,000 tons on 27ft 6in draught; twenty-four main cargo oil tanks, two pump rooms, steam-driven deck machinery; Harland-Burmeister and Wain single-acting, four-stroke diesel engine, six cylinders, 740mm diameter by 1500mm stroke, 115 r.p.m., two single-ended multitubular boilers. Trial, March 12th.

NADIA, buoy lifting and despatch vessel; built by William Simons and Co., Ltd., for the Commissioners for the Port of Calcutta; length between perpendiculars 200ft, breadth moulded 37ft, depth moulded 19ft 6in; two sets of triple-expansion, surface condensing engines, taking steam from Yarrow three-drum oil-fired boilers, speed 12 knots. Launch, March 12th.

British Patent Specifications

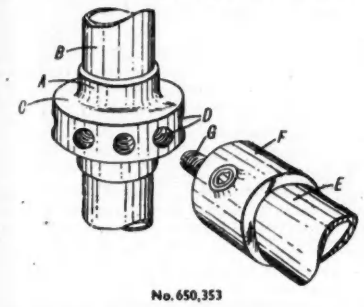
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery Lane, W.C.2, 2s. each.

STRUCTURAL ENGINEERING

650,353. September 22, 1948.—IMPROVEMENTS IN DEVICES FOR JOINTING TUBES AND BARS, The Geo. H. Gascoigne Company, Ltd., of Gascoigne House, Berkeley Avenue, Reading, and George Harry Gascoigne, of Queensmere, Wokingham, Berkshire.

This invention relates to devices for jointing tubes and bars for making skeleton frameworks or similar structures, allowing ready interchangeability. The accompanying drawing shows the components. A sleeve *A* can slide on a cylindrical tube *B*. The sleeve has an integral radial flange *C* which is of sufficiently large diameter to accommodate a series of tapped sockets *D*. Another tube which is to be jointed to the tube *B*



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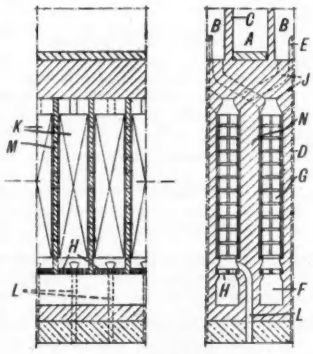
is provided at its end with a cap *F* having, at the closed end, a screw-threaded spigot *G*. This spigot is adapted to be engaged within any one of the tapped sockets in the flange to secure the tube in the position desired. In order to secure the sleeve *A* in a desired position at least one of the sockets *D* extends right through the flange to the bore of the sleeve so that a setscrew can be used to bind it on to the tube. The bore of the sleeve may also be relieved, so that the tube is pressed down on to the raised lands in the mouths of the sleeve. Several variations in the arrangement are described in the specification.—*February* 21, 1951.

COKE OVENS

650,348. August 5, 1948.—IMPROVEMENTS RELATING TO REGENERATORS, Simon-Carves, Ltd., of Bird Hall Lane, Cheadle Heath, Stockport, declares the nature of this invention (which has been communicated by *Dr. C. Otto and Comp. G.m.b.H., a German Company, of Bochum, Germany*).

In the group of ovens illustrated, the horizontal ovens *A* are arranged alternately with a series of vertical heating flues *B*, and are separated therefrom by the walls *C*. The fuel gas is led into the heating flues from beneath by means of the vertical passages *D* which open into the burners *E*. Air and diluted



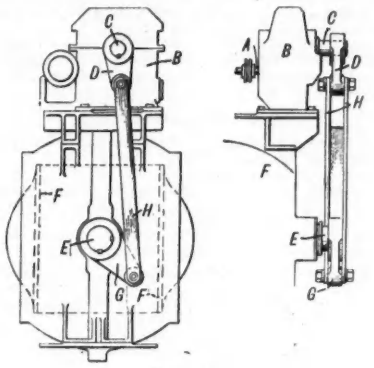
No. 650,348

gas can be fed through the passages *F* and then rise in the regenerator compartments *G*, which are filled with perforated bricks *H*. From the top of the compartments they enter the individual flues *B* by means of the distributing passages *J*. The burned gases travel downwards in the same manner from the heating flues into the passages at the bottom of the regenerators. The regenerator compartments *G* are divided by vertical partition walls into individual cells *K* and, in order to obtain a finer distribution of the gaseous fuel, the cells may be fed partly or wholly from below through the passages *L*. The vertical partition walls consist of flat bricks *M*, pairs of which overlap and form a layer and engage in the recesses of the regenerator compartment walls *N*.—*February* 21, 1951.

HYDRAULIC MACHINERY

650,280. May 20, 1948.—IMPROVEMENTS RELATING TO ROTARY VALVES FOR USE WITH WATER PIPES OR MAINS, Boving and Co., Ltd., of 56, Kingsway, London, W.C.2.

This invention relates to rotary throttle or butterfly valves having a predetermined varied rate of opening or closing, and in which the rate of closing is progressively reduced as the valve approaches the closed position. Referring to the drawings, an electric motor is direct coupled through a shaft *A* to a reduction gear *B*, and the drive or output drive shaft *C*. A crank *D*



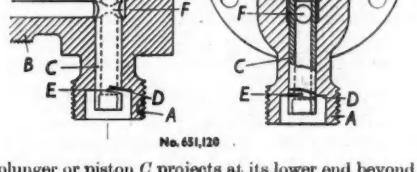
No. 650,280

is fixed to the end of the shaft which is parallel to the spindle *E* of the rotary valve *F*. A crank *G* is also secured to the outer end of the valve spindle *E* and connected to one end of a connecting-rod *H* pivoted at its other end to the crank *D* upon the shaft *C*. The crank upon the valve spindle is of greater length than the crank upon the shaft. The relative angular disposition of the two cranks is such that in the open position they are not parallel. In response to the rotation of drive shaft there is, through the two cranks and connecting-rod, an initial steady closure movement of the rotary valve. By predetermining the speed of the motor, the gear ratio of the reduction gear and the relative length and angularity or inclination of the cranks, the total closing time, and the reduced rate of closure of the valve are positively controlled. —*February* 21, 1951.

VALVES

651,120. December 9, 1948.—IMPROVEMENTS IN OR RELATING TO FLUID-ACTUATED VALVES, Richard Gleave Norris, of 45, Wallace Drive, Huyton, near Liverpool; Douglas Norris, of 16, Stonebridge Lane, Gill Moss, Liverpool, 11, and Charles Benson Sayer, 15, Princesway, Wallasey, Cheshire.

The invention has for its primary object the control of fluid flow in such a manner as to maintain automatically the rate of flow substantially constant independently of variation, within predetermined limits, of the pressure in the fluid supply line leading to the valve. In the construction illustrated, the inlet port of the valve is shown at *A*. The outlet port of the valve is shown at *B*. The



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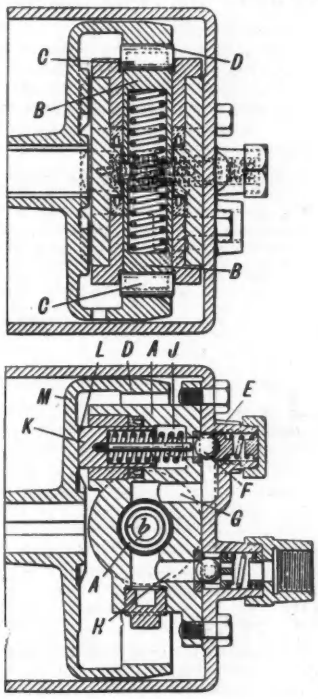
plunger or piston *C* projects at its lower end beyond a shoulder *D* at the end of the bore in the valve housing. A transverse and segmental slot *E* is provided adjacent the lower end of the plunger, whilst a radial or diagonal bore *F* is provided at the other end. Fluid communication is established between the slot and bore by a longitudinal bore in the plunger to enable fluid to flow from the inlet port to the outlet port when the slot *E* lies partially or wholly below the shoulder. The lower end of the bore in the plunger is closed by a threaded plug so that the bore in effect extends merely from the slot to the transverse bore. The selected transverse area of the segmental slot *E* should be dependent on the volume of fluid which it is desired should pass through the valve per unit of time. For the purpose of minute adjustment in reducing variation of flow from the valve to an absolute minimum independently of pressure variations in the fluid supply line the slot *E* extends at a small angle to a transverse plane lying normal to the axis of the plunger and preferably also at a similarly small angle to the same plane, but in a direction normal to the first angle. The rear of the slot terminates in a relatively fine cut which, like the slot, is both inclined and undercut to increase the effect of undercutting of the slot, particularly at relatively high pressures. The resilient load on the valve plunger may be effected by a diaphragm or by a cap which is either spring loaded or is inherently resilient. In the construction illustrated a rubber cap *G* is secured to the end of the plunger and is held at a flanged portion between a seating in the valve housing and a washer at the base of an adjustable closure cap. Preferably, and as shown in the drawings, a brass or other rigid ring *H* retains the end of the plunger within the cap. This form of construction has the particular advantage in that the degree of resilience of the cap may be varied to assist in presetting the position of the valve plunger prior to use. Thus, in the position shown where the ring encircles the cap in the region of the head of the plunger, it has the effect of rendering the cap less resilient than it would be in the case of encircling the cap at its top. It will, of course, be appreciated that displacement of the plunger is effected not only by the fluid pressure acting on the lower or inlet end of the plunger, but also by the pressure of the cap at the outlet end of the plunger. —*March* 14, 1951.

PUMPS

651,112. October 20, 1949.—IMPROVEMENTS IN AND RELATING TO RECIPROCATING PUMPS, Foster, Yates and Thom, Ltd., Canal Works, Blackburn, Lancashire, and Herbert Dowell, of the company's address.

The pump comprises a fixed casing to which is secured a body *A* in which two opposed plungers *B* are mounted to slide in bushes. The plungers are held apart by a coil spring, and rollers *C* in grooves in the ends of the plungers run on an internal cam surface *D* of a revolving drum and



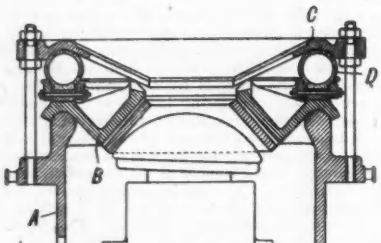
No. 651,112

cause the plungers to reciprocate. Fluid enters through a boss *E* and into a chamber *J*, passes through a ball valve *F* and passages *G* to the space between the plungers, which pump it through passages *H* to an outlet ball valve. The chamber *J* is formed in the body mounted to slide in the casing. A plunger *K* is held by a spring in contact with a cam surface *L* in the revolving drum *M*. Fixed to the plunger is a rod which lifts the inlet ball valve off its seat at appropriate intervals as the plunger is displaced by the cam.—*March* 14, 1951.

MISCELLANEOUS

651,212. December 30, 1947.—IMPROVEMENTS IN GYRATORY CRUSHERS, Johan Alfred Bjarme, 9 Hästholmsvägen, Stockholm, Sweden.

The gyratory crusher frame *A* carries a concave crusher member *B* and has bolted to it a frame member *C*. The concave crusher head has on its upper side an annular groove serving as a support for a hollow pneumatic rubber ring *D*. Bearing against the upper side of this ring is the fixed frame member *C*. When abnormally high crushing pressures are met in operation



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the member *B* is lifted so as to compress the pneumatic ring, and on reduction of the pressure the ring expands to force the member back to its normal working position. In another embodiment of the invention the frame member has a number of cylindrical bores containing tightly fitting plungers which press the crusher member downwards against the frame. The cylindrical bores intercommunicate by a passage connected to a compressed air supply. When air of a suitable pressure is introduced into the cylindrical bores the frame will have a yielding action under excessive crushing pressures.—*March* 14, 1951.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Association of Supervising Electrical Engineers

Mon., April 2nd.—N.E. LONDON BRANCH: Angel Hotel, Ilford, "The Use of Electricity in Ships," C. P. Harrison, 8 p.m.——SHEFFIELD BRANCH: Royal Victoria Hotel, Sheffield, "Some Industrial Applications of Electronics," A. Southern, 7.30 p.m.
Tues., April 3rd.—W. LONDON BRANCH: Town Hall, Hammersmith, "Problems of Television," R. Stevens, 7.30 p.m.
Wed., April 4th.—N. LONDON BRANCH: "Three Jolly Butchers" Hotel, Wood Green, N.22, "Radar," E. Fennessy, 8.15 p.m.
Thurs., April 5th.—S. LONDON BRANCH: Cafe Royal, North End, Croydon, "Electric Lifts," L. S. Atkinson, 8 p.m.
Fri., April 6th.—LIVERPOOL BRANCH: Electricity Showrooms, Whitechapel, Liverpool, "Methods of Assessing and Charging for Electrical Energy," B. R. Campbell-Kelly, 7 p.m.

British Institution of Radio Engineers

Wed., April 4th.—MERSEYSIDE SECTION: Electricity Service Centre, Whitechapel, Liverpool, "The Silicon Carbide Resistor as a Circuit Element," W. Needham, 7 p.m.
Thurs., April 5th.—SCOTTISH SECTION: Institution of Engineers and Shipbuilders, Elmbank Crescent, Glasgow, "Rare Elements in Radio and Electronics," D. A. Wright, 6.45 p.m.

Engineer Buyers' and Representatives' Association

To-day, Mar. 30th.—Waldorf Hotel, Aldwych, London, W.C.2, annual general meeting, 6 p.m.

Engineers' Guild

Thurs., April 5th.—YORKSHIRE BRANCH: Royal Victoria Hotel, Sheffield, "The Aims and Achievements of the Engineers' Guild," W. L. Henderson, 7 p.m.

Illuminating Engineering Society

To-day, Mar. 30th.—BIRMINGHAM CENTRE: Imperial Hotel, Temple Street, Birmingham, "Interesting Applications of Photometry and Colorimetry," G. F. Lothian, 6 p.m.
Mon., April 2nd.—LEEDS CENTRE: Lighting Service Bureau, 24, Aire Street, Leeds, 1, Annual General Meeting, followed by Film Show, 7 p.m.
Tues., April 3rd.—SHEFFIELD CENTRE: The University, Weston Bank, Sheffield, "Some Aspects of Illuminating Engineering," W. R. Stevens, 6 p.m.
Wed., April 4th.—NEWCASTLE CENTRE: Minor Durrant Hall, Oxford Street, Newcastle upon Tyne, Annual General Meeting, 6.15 p.m.——SWANSEA GROUP: 4, Northampton Gardens, Swansea, "Colour and Lighting," S. A. Wood, 5.45 p.m.
Thurs., April 5th.—CARDIFF CENTRE: S. Wales Electricity Board, The Hayes, Cardiff, "Colour and Lighting," S. A. Wood, 5.45 p.m.
Fri., April 6th.—BATH AND BRISTOL CENTRE: Grand Hotel, Bristol, Presidential Address, L. J. Davies, 7 p.m.——HUDDERSFIELD GROUP: Electricity Showrooms, Market Street, Huddersfield, "Safety and Vision," E. W. Murray, 7.15 p.m.

Incorporated Plant Engineers

To-day, Mar. 30th.—BIRMINGHAM BRANCH: Imperial Hotel, Temple Street, Birmingham, annual general meeting; film, "Prelude to Power," 7.30 p.m.
Mon., April 2nd.—LONDON BRANCH: Royal Society of Arts, John Adam Street, Adelphi, W.C.2, "Electronic Motor Control," 7 p.m.
Tues., April 3rd.—S. WALES BRANCH: Grand Hotel, Westgate Street, Cardiff, "High-Pressure Hot Water Installations," B. Pheasant, 7.30 p.m.
Thurs., April 5th.—PETERBOROUGH BRANCH: Eastern Gas Board's Demonstration Theatre, Church Street, Peterborough, Film, "CO_2 and Draught," W. S. Hudson, 7.30 p.m.

Institute of British Foundrymen

Sat., Mar. 31st.—WALES AND MONMOUTH BRANCH: Engineers' Institute, Cardiff, "Steel Foundry Practice," G. T. Hampton, 6 p.m.
Mon., April 2nd.—SHEFFIELD BRANCH: Royal Victoria Hotel, Sheffield, "Repair and Reclamation of Iron Castings by Welding and Allied Methods," 7.30 p.m.

Institute of Economic Engineering

To-day, Mar. 30th.—The Bulstrode Hotel, Hounslow, Discussion Group meeting, 7 p.m.——BOLTON BRANCH: Technical College, Bolton, "The Wider Application of Incentives," E. Hollinghurst, 7.30 p.m.
Tues., April 3rd.—Rotherham House Hotel, Sheffield, "The Function of the Personnel Officer," Miss Pearson, 7.45 p.m.

Institute of Fuel

Tues., April 3rd.—Institution of Mechanical Engineers, Storey's Gate, St. James's Park, S.W.1, "Underground Gasification," C. A. Masterman, E. T. Wilkins and J. L. Elder, 5.30 p.m.

Institute of Industrial Supervisors

To-day, Mar. 30th.—CARDIFF SECTION: Technical College, Cardiff, "Production Lay-out and Material Handling," A. J. Mansell, 7 p.m.
Wed., April 4th.—LEEDS SECTION: Technical College, York, "Modern Foremanship," H. R. Harbott, 7.30 p.m.
Thurs., April 5th.—WARRINGTON SECTION: White Hart Hotel, Warrington, Members' Discussion Night, 7 p.m.

Institute of Marine Engineers

Mon., April 2nd.—85, Minories, London, E.C.3, Annual General Meeting, 5.30 p.m.

Institution of Civil Engineers

Tues., April 3rd.—Great George Street, Westminster, S.W.1, "The Structural Design of the 'Dome of Discovery,' Festival of Britain, 1951," Gilbert Roberts 5.30 p.m.

Institution of Electrical Engineers

To-day, Mar. 30th.—N.E. STUDENTS' SECTION: Grey Hall, King's College, Newcastle upon Tyne, "The Reduction of Reactive Energy Losses by Means of Capacitors," G. P. Cundall, 5.30 p.m.
Mon., April 2nd.—RADIO SECTION: Savoy Place, Victoria Embankment, W.C.2, "The Automatic Monitoring of Broadcast Programmes," H. B. Rantzen, F. A. Peachey and C. Gunn-Russell, 5.30 p.m.——N.E. CENTRE RADIO AND MEASUREMENTS GROUP: King's College, Newcastle upon Tyne, Annual General Meeting, 6 p.m.——Address on the Symposium of Papers on "Electrical Meteorological Instruments," J. F. Coales, 6.15 p.m.——S. MIDLAND CENTRE: James Watt Memorial Institute, Great Charles Street, Birmingham, "Determination of Time and Frequency," Humphrey M. Smith, 6 p.m.
Tues., April 3rd.—MEASUREMENTS SECTION: Savoy Place, Victoria Embankment, W.C.2, "An Electronic Process Controller," J. R. Boundy and S. A. Bergen, 5.30 p.m.——SCOTTISH CENTRE: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "The Design Specification and Performance of High-Voltage Surge Diverters," H. F. Jones and C. J. O. Garrard, 7 p.m.——N. MIDLAND CENTRE: British Electricity Authority, Whitehall Road, Leeds, 1, "Recent Ideas and Experiments in Magnetism," L. F. Bates, 6.30 p.m.
Thurs., April 5th.—Savoy Place, Victoria Embankment, W.C.2, "The Development of the Electrical System on the Bristol 'Brabazon' Mark I Aircraft," J. J. Cronin, 5.30 p.m.

Institution of Heating and Ventilating Engineers

To-day, Mar. 30th.—MANCHESTER AND DISTRICT BRANCH Town Hall, Manchester, "The Caterole Plant," 6.30 p.m.
Wed., April 4th.—Institution of Mechanical Engineers, Storey's Gate, St. James's Park, S.W.1, "The Sunshine Problem in Air Conditioning," N. S. Billington, 6 p.m.——E. MIDLANDS BRANCH: School of Technology, Leicester, "Heating Research in Occupied Houses," J. C. Weston, 6.30 p.m.

Institution of Mechanical Engineers

To-day, Mar. 30th.—Storey's Gate, St. James's Park, S.W.1, annual general meeting (corporate and non-corporate members only), 5.30 p.m.
Wed., April 4th.—N.W., A.D. CENTRE: The University, Liverpool, "The Performance and Weight of Automobile Petrol Engines," Donald Bastow, 7.15 p.m.
Thurs., April 5th.—GRADUATES' SECTION: Storey's Gate, St. James's Park, S.W.1, "How Fluid Friction Affects the Engineer," N. Bradley, 6.30 p.m.——S. WALES BRANCH: S. Wales Institute of Engineers, Cardiff, "Recent Trends in Industrial Design," K. L. Brookfield, 6.30 p.m.
Fri., April 6th.—Storey's Gate, St. James's Park, S.W.1, "Load Distribution in Riveted and Spot-Welded Joints," D. Williams, "Design Stresses in Fillet Weld Connections," F. Koenigsberger, 5.30 p.m.

Institution of Mechanics

Wed., April 4th.—Technical College, Enfield, "Mass-Production of Pinions and Gears," S. V. Fountain, 8 p.m.

Institution of Production Engineers

Tues., April 3rd.—READING SUB-SECTION.—Great Western Hotel, Reading, "The Refinery of Oil," I. A. B. Pender, 7.15 p.m.——LINCOLN SECTION: Ruston and Hornsby, Ltd., Boultham Works, Lincoln, Annual General Meeting, 7 p.m.
Wed., April 4th.—LONDON GRADUATE SECTION: 36, Portman Square, W.1, "Developments in Machine Tool Controls," F. H. R. Koeller, 7.15 p.m.——NOTTINGHAM SECTION: Victoria Station Hotel, Milton Street, Nottingham, "Vehicle Maintenance," 7 p.m.——S. ESSEX SUB-SECTION: Conservative Club, Ilford, "The Control of Quality in Medium and Large Quantity Engineering Production," J. Loxham, 7.30 p.m.——WOLVERHAMPTON SECTION: Technical College, Castle View, Dudley, "Modern Adhesives," Mr. Johnson, 7 p.m.
Thurs., April 5th.—LONDON SECTION: Old Ship Assembly, Brighton, "The Financial Aspect of Machine Tool Replacement," R. McNeil, 7 p.m.
Fri., April 6th.—LUTON GRADUATE SECTION: Library Lecture Hall, Williamson Street, Luton, "Spinning a Yarn"—Cotton Manufacture, J. Horridge, 7.30 p.m.—COVENTRY GRADUATE SECTION: Geisha Cafe, Hertford Street, Coventry, "Plastic Materials in Production," A. Beecham, 7.15 p.m.

Institution of Structural Engineers

To-day, Mar. 30th.—MIDLAND COUNTIES BRANCH: James Watt Memorial Institute, Great Charles Street, Birmingham, "The Solution of the Car Parking Problem Here and in the U.S.A.," W. P. Andrews and P. G. Bowie, 6 p.m.——WALES AND MONMOUTHSHIRE BRANCH: County Buildings, Colwyn Bay, "Structural Engineering at Abbey Works," A. V. Hooker, 6 p.m.
Tues., April 3rd.—NORTHERN COUNTIES BRANCH: Cleveland Scientific and Technical Institution, Corporation Road, Middlesbrough, Annual General Meeting, 6.30 p.m.——N. IRELAND BRANCH: College of Technology, Belfast, Annual General Meeting, 7.15 p.m.
Fri., April 6th.—WESTERN COUNTIES BRANCH: Grand Hotel, Bristol, Annual General Meeting, 6.15 p.m.

Institution of Water Engineers

Wed., April 4th.—S.E. SECTION: Institution of Civil Engineers, Great George Street, Westminster, S.W.1, Annual General Meeting, "Prestressed Concrete and its Use in Water Retaining Structures," P. G. Barrie, 2.30 p.m.

Institution of Works Managers

Tues., April 3rd.—SHEFFIELD BRANCH: Sheepbridge Engineering Company, Ltd., Chesterfield, "The Value of Publicity in the Works," R. Pugh, 7 p.m.

Iron and Steel Institute

Thurs., April 5th.—4, Grosvenor Gardens, S.W.1, "Electric Drives for Reversing Hot Mills," P. E. Peck, 10.30 a.m. to 12.45 p.m.; "Hot Bloom and Slab Shears," J. A. Kilby, 2 p.m. to 4.30 p.m.

Junior Institution of Engineers

Wed., April 4th.—MIDLAND SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham, "Engineering Practice in the Production of Tyre Moulds," T. F. Luck, 7 p.m.
Fri., April 6th.—39, Victoria Street, S.W.1, Films, "Precision Machine Tools," "Metallic Bearing Surfaces," S. G. Jennings and F. Baxter, 6.30 p.m.

Liverpool Metallurgical Society

Thurs., April 5th.—Electricity Service Centre, Whitechapel, Liverpool, Annual General Meeting, 7 p.m.

North-East Coast Institution of Engineers and Shipbuilders

To-day, Mar. 30th.—Mining Institute, Newcastle upon Tyne, "Forging Methods," J. C. Stevens, 6.15 p.m.

Societe des Ingenieurs Civils de France

Thurs., April 5th.—Institution of Structural Engineers, 11, Upper Belgrave Street, S.W.1, "The Tuscan Boracic 'Soffioni' and their Development at Landerello," Alfredo Mazzoni, 6 p.m.

Society of Engineers

To-day, Mar. 30th.—17, Victoria Street, Westminster S.W., "Some Waterproofing Problems," I. Hopkins "Competitive Design of Steel Structures," J. C. Maxwell Cook, 6.30 p.m.
Mon., April 2nd.—Geological Society, Burlington House, Piccadilly, W.1, "Experimental Stress Analysis Applied to Pressure Vessel and Pipe Line Problems," Nicol Gross, 5.30 p.m.